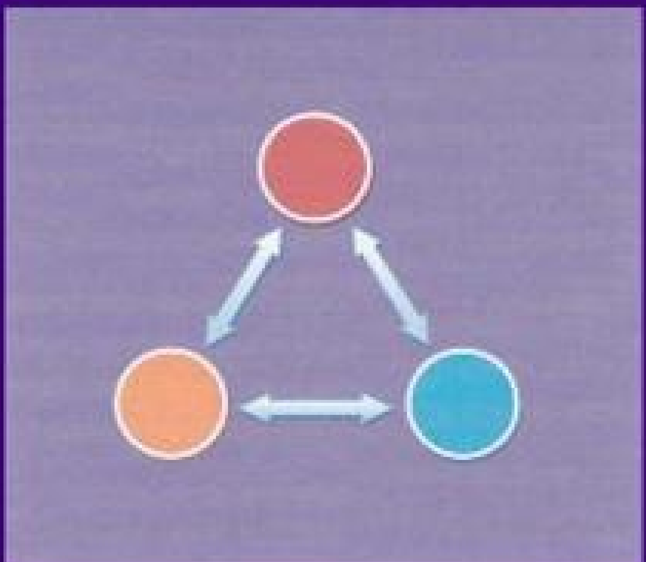
Universe without Space and Time

An Essay on Principles for Relational Cosmology Drawn from Catholic Tradition and Empirical Science



Victor P. Warkulwiz, M.S.S.

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An Essay on Principles for Relational Cosmology Drawn from Catholic Tradition and Empirical Science

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Cover: The triangular logo represents relational cosmology. It is inspired by the doctrine of the Most Holy Trinity. The triangle has long been the symbol of the Trinity. Each vertex represents a Divine Person and the lines help express their relations. These relations are what constitute the distinction between the Persons. They cannot be distinguished by any attribute because each Divine Person possesses the one unique infinite Divine Nature completely to Himself. Whatever distinction there is must be in their relations alone. Analogously, in relational cosmology each celestial body in the universe is not distinguished from the others by their locations on an absolute space-time grid. Rather, each one possesses the one unique universal plenum completely to itself, and it can only be distinguished from others by their relations with it on its own space-time grid. And, like in the Trinity, these relations are ultimately a mystery.

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ABOUT THE BOOK

This essay is entitled *Universe without Space and Time* because it proposes a cosmology that discards the notion that space and time are independent entities, either in Newton's sense of absolute space and time or in Einstein's sense of a self-subsistent space-time manifold. Instead, it treats space and time as relational quantities that are wholly dependent on matter for their meaning. It develops the scholastic way of thinking about space and time, which is the fruit of meditation on the biblical account of creation, and results in a way of looking at the cosmos that is refreshingly different from that of modern cosmology. It is an essay on principles, which means that it is not a full-blown cosmology but starting points for a Catholic biblically-inspired cosmology. The principles are drawn from Sacred Scripture as interpreted in Catholic Tradition (as passed on by the Fathers, Doctors and Magisterium of the Church) and from the observations of empirical science. It may be that more than one consistent cosmology can emerge from the principles because they may not be powerful enough or complete enough to produce a unique cosmology

The content of the essay is conceptual and non-mathematical. It is directed to the scientifically literate reader, both professional and lay. Although written from a Catholic perspective, the book is intended to appeal to believers of all faiths that hold Genesis to be the inerrant Word of God. Even readers who do not agree with the theme of the book will find much in it that enhances their understanding of the natural world.

INTRODUCTION

This essay is a sequel to my previous work *The Doctrines of Genesis 1-11: A Compendium and Defense of Traditional Catholic Theology on Origins*. I call this work an “essay” because it presents a personal point of view that is not to be interpreted as religious or scientific dogma. The principles I set forth are drawn from Sacred Scripture as interpreted in Catholic Tradition (as passed on by the Fathers, Doctors and Magisterium of the Church) and from the observations of empirical science. I appeal to empirical science rather than theoretical science because the latter is often based more on ideas than facts.

I had no intention whatsoever of formulating a new cosmology, but in doing research for *The Doctrines of Genesis 1–11* a new cosmological picture began to form in my mind. I also discovered that the cosmological questions asked by the ancient and medieval scholars were more pertinent to understanding the cosmos than those asked by modern scientists. Since the seeds of my thought are in *The Doctrines of Genesis 1–11*, I have borrowed liberally from that work, in some cases whole passages verbatim.

I’ve always found modern books on space and time boring because the ideas are drawn from impoverished and godless doctrines of the Enlightenment. Modern science, which employs those doctrines, is out of its depth when it pontificates on the nature of space and time because the true nature of space and time lies outside the set of ideas that confines it.

I hope the reader will find this work less boring than I have found those works. I made every effort to stick to the truths of divine revelation and the empirical facts, both of which work together to give us the most complete and accurate picture of the cosmos that is possible in this life. And such a picture is not boring but awesome and beautiful because it is the work of God and is recognized as such.

I entitled this essay *Universe without Space and Time* because it proposes a cosmology that discards the notion that space and time are independent entities, either in Newton’s sense of absolute space and time or in Einstein’s sense of a self-subsistent space-time manifold. Instead it treats space and time as relational quantities that are wholly dependent on matter for their meaning. What all this means should become clearer as the reader proceeds through the essay. Suffice it to say now that it develops the

scholastic way of thinking about space and time, which is the fruit of meditation on the biblical account of creation.

In the subtitle I say that it is an essay on “principles.” By this I mean that I am not offering a full-blown cosmology but only starting points for a Catholic biblically-inspired cosmology. It may be that more than one consistent cosmology can emerge from these principles. The principles may not be powerful or complete enough to produce a unique cosmology.

In the first chapter I discuss medieval notions of place and time and the enlightenment notions of absolute space and time. The former are based on divine revelation; the latter are based on human ideas and ignore divine revelation. In the second and third chapters I discuss the biblical notion of the earth as the center of rest in the universe and how this is misunderstood. In the fourth chapter I discuss the logic of Newtonian and relativistic physics and their common errors that lead to a false picture of the cosmos. In the fifth chapter I discuss relational physics, which treats space and time as epiphenomena (or accidents) of matter and is consistent with traditional Catholic doctrine. Finally, in the conclusion I collect and summarize the principles that have been put forth.

Rev. Victor P. Warkulwiz, M.S.S.

CHAPTER ONE: MEDIEVAL AND ENLIGHTENMENT NOTIONS ABOUT PLACE, SPACE AND TIME

Medieval Biblical Theology and Enlightenment Ideology

The High Middle Ages (12th–13th centuries) was a period of great intellectual activity in Europe. Under the sponsorship of the Church, Catholic scholars pursued studies in a wide variety of subjects that included both the spiritual and physical aspects of reality. One field of interest was natural philosophy, which was concerned with knowledge about the material world. The medieval scholar observed the world with his limited technical means of observation. He interpreted his observations in light of the biblical record, using the Fathers of the Church as trustworthy exegetical guides. Thus, his foundation for the study of creation was biblical theology. He also employed the insights of Greek authors, such as Plato and Aristotle, Arabic authors, such as Avicenna and Averroes, and Jewish authors, such as Philo and Maimonides. The beginnings of experimental science are found in the work of Robert Grosseteste and Roger Bacon. The reasoning of medieval scholars was guided by divine revelation as proclaimed in Sacred Scripture, Sacred Tradition, and the official decrees of the Church. The doctrines of the faith disciplined reason and prevented it from going wild. Because of the widespread and wholehearted acceptance of the Catholic faith by the European people of that era, the High Middle Ages has come to be called the Age of Faith

The Enlightenment (17th–19th centuries) was a period of wholesale rejection of medieval scholasticism and traditional authority by many of the influential intellectuals of Europe. It was characterized by scientific, philosophical, religious and rational attitudes that departed significantly from those of the Christian Middle Ages. The major figures (literary men, scientists and philosophers) of the Enlightenment were united in their belief in the supremacy of reason. In France, their verbal and written attacks on the government and the Church impelled the physically violent attacks of the French Revolution. In England the Enlightenment took the form of a cold scientific intellectualism, which produced some advances in scientific methods but also introduced seriously flawed scientific notions such as biological transformism and uniformitarian geology. Because of the divinization of the human mind by so many of the intellectuals of the era, the Enlightenment has come to be called the Age of Reason.

Enlightenment ideology is a way of thinking that was conceived in the humanism of the Renaissance (14th–17th centuries), born in the rationalism

of Enlightenment, came of age in the atheism of the Modern Era (19th–20th centuries), and has reached adulthood in the neo-paganism of the Postmodern Era (21st century). It is the attitude of mind inherited by modern scientists, including the many Christian ones who compartmentalize it in their scientific work. Enlightenment ideology is

1. *ideological* because it places total confidence in its own set of human ideas and none in divinely or humanly established authority;
2. *rationalistic* because it holds that human reason is the supreme arbiter of truth;
3. *naturalistic* because it holds that the world *alone* can tell us everything there is to know about it;
4. *materialistic* because it asserts that all manifestations of the supernatural (such as miracles and design in nature) are explainable by physical causes, even if those causes cannot be identified;
5. *scientistic* because it places exaggerated trust in efficacy of the methods of natural science, and it condescendingly applies those methods to other fields of knowledge.

Enlightenment ideology pilots modern science. The study of nature today is guided exclusively by observation, experiment, and ideologically-governed reason. Divine revelation is excluded as a source of knowledge; human ideas replace divine revelation. Observation and experiment have been enhanced by modern technical innovations, but those are products of discovery and tinkering, not of enlightenment ideology.

Enlightenment Ideology and Natural Truth

Enlightenment ideology succeeds admirably in inventing methods for squeezing facts out of nature. But it fails miserably in the interpretation of those facts. It succeeds in the former because it meticulously conforms itself to naturally revealed truth. It fails in the latter because it resolutely refuses to be informed with divinely revealed truth.

Enlightenment ideology, by not allowing itself to be guided by divine revelation, has sent science off in the wrong direction in a number of areas. By rejecting the creation account in Genesis 1 it has given a false cosmology and a false biology. Genesis 1 clearly teaches that the universe was created and formed over a period of six days; living creatures were created instantly, each with a complete fixed living nature. That picture is direct opposition to that given to us by big bang cosmology and evolutionary biology, which tell us that the celestial creatures were formed over billions of years and that the living creatures continually transform into creatures with more and more complex natures. Unbiased observation of the natural world clearly supports the biblical picture. This is shown in many places.

The rejection of the account of the creation of man in Genesis 2 by enlightenment ideology has led to false anthropology, false psychology and false sociology. Genesis 2 clearly teaches that the first man and woman were specially created by God, who gave them a nature that was both material and spiritual. This gave them a nature that was different in kind and not only degree from all the other members of the animal kingdom. This difference is made manifest in the intellectual and volitional life of the human being. God made the first man and woman persons, like Himself. In their intellectual and volitional life and personhood, God made the first couple images of Himself. But modern “enlightened” anthropology denies this. It sees the human being, either wholly or in its material component, as having “evolved” from lower forms of life through an innumerable (and unobserved) succession of intermediate forms. It sees the spiritual element in man (the soul) either as an illusion or as an epiphenomenon of matter, having gradually emerged from it. This view has led to a purely animalistic human psychology, which views human personhood as little more than a succession of conscious states. This aberrant psychology manifests itself in erroneous sociological notions. For example, in totalitarian states, inspired

by evolutionary biology, people have been deprived of their rights as persons and treated solely as servants to the community, like a bees in a hive. Also evolutionary biology inspired the notion that animals have rights, just like human beings. Some extreme activists even see animals as having a priority in rights over humans simply because they were here first. These and other bizarre notions are the spawn of evolutionary biology.

The rejection of the biblically-attested fact that the world was completely destroyed by a universal flood as related in Genesis 6-8 has given rise to a false geology, namely uniformitarian geology. Uniformitarian geology insists that the features on the earth were produced by slow processes acting over millions of years and not by a worldwide catastrophe like the great flood. The geological data, however, provide strong evidence in favor of a worldwide catastrophe.

By rejecting the primal history of the human species as related in Genesis 9-11, enlightenment ideology has misled archaeology, preventing it from giving proper interpretations to its data. And by rejecting the account of the origin of languages given in Genesis 11, enlightenment ideology has further misguided cultural anthropology.

By presuming that the earth moves absolutely in space around the sun, in conflict with Sacred Scripture, astronomers pretend to measure distances to celestial objects. Since they cannot demonstrate that the earth moves absolutely, their results are inconclusive. Yet they present their distances as if they were unquestionable facts.

Finally, by not drawing the proper inferences from the creation account in Genesis 1, modern physics has given us false notions about the nature of space (or void) and time. Medieval thinkers, like St. Thomas Aquinas, guided by the scriptural record, formed correct notions about space and time but did not develop them. The present work is a beginning of such a development in the light of current knowledge.

Medieval Notions of Place and Void

Medieval scholars did not employ the concept of free space that we have inherited from the Enlightenment, even though it had been conceived in antiquity by the Greek atomists. So to understand how they thought, we must do our best to set aside our concept of free space. This is very difficult indeed because it is so deeply ingrained in our minds and imagination. We can hardly believe that there can be any other way to conceive the universe than as being imbedded in an independently-existing three-dimensional void.

To condition yourself for a change in perception do the following thought experiment: Image yourself being present on the first day of Creation. The material universe consists of the earth alone, which is completely covered with water. God equips you with scuba gear and a few devices and places you beneath the surface of the water. This is where you come to consciousness. You start to test your environment by letting go of a few hollow rubber balls that God gave you. You find that they float up to a certain point and go no further. Thus you deduce that where they stopped is the boundary of the universe in which you were placed. At this point you can't imagine anything being beyond there because nothing you have experienced so far suggests that there is. You name the region where the balls stopped the "surface" of the water. It is the boundary that defines the "place" where you live.

*

The concept of *place* held much significance for medieval scholars. Their conceptions of place were built on that of Aristotle. Aristotle struggles with the notion of *place* in Book IV of his *Physics*. He concludes by defining it as follows: Place is "the innermost motionless boundary of what contains" [1, p. 278]. So in our thought experiment so far, the complete surface of the water contains the place of the earth; but that surface itself does not have a place because nothing contains it.

Aristotle goes on to say that only movable bodies have a place. The term "movable" has no meaning on the first day of Creation because then only the earth existed. At least two bodies must exist for the word motion to have meaning. So the question of whether or not the earth moves will be

moot until the fourth day of Creation, when the heavenly bodies are created. Sacred Scripture tells us that God made the earth the standard of rest in the universe, but this does not mean that the earth is incapable of being moved. We can feel free to apply Aristotle's definition of place to it, even on Day One.

For a summary of Aristotle's views on space and place see [2].

Pierre Duhem gives a comprehensive survey of medieval notions about place in chapters 4–6 of [3]. Duhem points out that there was ample development of the theory of place at the University of Paris in the middle of the thirteenth century. Especially interesting are the views of St. Thomas Aquinas. In a discussion of the motions of the heavens around the earth, in his *Expositio super libros De Caelo et Mundo*, he makes the observation that the center of rotation must exist in a corporeal body. St. Thomas said:

> There has to be something remaining immobile at the center of a body moving circularly. It is evident that any circular movement occurs around a fixed center. And it needs to be that this center is located in a fixed body, for what we call the center is not something subsisting in itself. It is an accident belonging to something corporeal; this center can only be the center of a body. [3, p. 153]

Aquinas goes on to say that the rotations of the heavens would be a meaningless notion if the earth did not exist:

> This fixed body must be part of the world … but it cannot be part of the mobile orb, meaning the celestial body.… That which is at the center is eternally immobile, as heaven moves eternally.… And that which is naturally immobile at the center is the earth.… Therefore, if heaven revolves eternally, the earth has to exist. [3, p. 153]

Aquinas sees the notion of place as intimately connected with the motion of corporeal bodies. In his *In libros Physicorum Aristotelis* he states:

> Place would not be investigated if it were not for movement; movement calls attention to place because bodies succeed each

> other in one place. Hence although a body does not of necessity have a place, nevertheless, a body moved with respect to place does have a place of necessity. Therefore, it is necessary to assign a place to a body moved in place insofar as one considers in that movement a succession of various bodies in the same place. Thus in things moved in a straight line, it is clear that two bodies succeed each other in place with respect to the whole. For the whole of one body leaves the whole place and into that whole place another body enters. Hence it is necessary that a body moved in a straight line is in place with respect to its whole self. [3, p. 154]

Aquinas accepted the geocentric cosmology of Aristotle and Ptolemy, as did apparently all of his contemporaries. Thus the movements that he was primarily interested in were the circular movements of the heavens. The heavens were thought to move around the earth like spherical shells. The ultimate or final celestial sphere was thought by some to have a place; others reasoned it had no place because it did not and could not exhibit local movement but only circular movement. Aquinas, further on in *In libros Physicorum Aristotelis*, gives his view:

> Therefore in circular movement attention is directed to the succession in the same place, not of whole bodies, but of parts of the same body. Hence for a body moved in a circle, a place with respect to the whole is not due of necessity, but only in respect of the parts.… Moreover it is much more suitable to say that the ultimate sphere is in place because of its own intrinsic parts than because of the center which is altogether outside of its substance; and this is more consonant with the teaching of Aristotle. [3, p. 154]

A paradox that vexed the medieval scholars was the notion that, according to Aristotle, place was at once both movable and immovable. It seemed moveable because it was somehow attached to the body in motion. It seemed immovable because another body moved into it after a first body left it. Aquinas resolved the paradox by considering that place has two senses, one referring to the body itself and the other referring to ambient

bodies. The first means that for a place to exist there must be a body to be in place; that is, there is no such thing as absolute place, place without a physical body. The second means that a body has a relationship to other bodies that is called place. In *De natura loci*, which is attributed to St. Thomas, the author explains that the "set of celestial bodies" is the reference base for identifying an immobile place:

> That is the way in which we ought to understand that the extreme parts of natural bodies form the place of other bodies; they form it in virtue of the relative position, the order, and location that they present with respect to the set of celestial bodies. The latter is the natural container, the principle of conservation and all location. [3, p. 156]

Thus if two bodies, at different times, possessed the same relationships with the "set of celestial bodies," they can be said to have been in the same place. In *De natura loci* St. Thomas elaborates a bit more on the place of the ultimate sphere. He says that the ultimate sphere is in a place *accidentally* because its parts are in place, albeit potentially and not actually. A thing is in a place accidentally by being attached somehow to something that is in a place.

As Thomistic doctrine was developed by later medieval masters, it became clear that to be able to identify an immobile place, the reference base itself must be immobile. Thus the universe must be bounded by an immobile spherical surface. According to Duhem [3, pp. 169, 178], the "natural conclusion of the Peripatetic theory of place" is "the hypothesis of a necessarily immobile empyrean sphere." Theologians had no difficulty with that concept. Some of them even thought that Sacred Scripture affirmed the existence of such a sphere. St. Bonaventure in commentary on Peter Lombard's *Sentences* spoke of an immobile orb "which contains and is not contained" [3, 174]. This notion was taken up later by Copernicus. But he did not take the empyrean sphere as the immobile reference for movements of the celestial bodies. Rather he took the sphere of the fixed stars.

In his *Writings on the "Sentences" of Peter Lombard* Aquinas sets forth his view that what is called place or space is defined by the objects in it and was created with the world. He makes the further observation that what we

call void is not a simple negation but a privation and is neither self-existent nor created; more will be said later about the notion of void:

> [I]t ought to be said that before the creation of the world there was no void, as there is none after, because the void is not a simple negation but a privation. Hence, in order that there be a void, as those who suppose that there is one would say, there must be a place or real dimensions, neither of which did exist before the world. [4, p. 97]

In his *Summa Theologica* Aquinas reaffirms his view that place or space was created in the beginning:

> Whereas we hold that there was no place or space before the world was. [5, Part I, Q. 46, A. 1, Reply Obj. 4]

*

Let us return now to our thought experiment. Imagine that God has also provided you with a rod. You go close to the surface of your world and poke at it with the end of your rod. To your amazement you find that the rod shortens. You then pull the rod back toward you and find that it has returned to its full length. Your first deduction might be that the rod shrinks as it makes contact with the surface. You then find that God has provided you with another rod, one that is not uniformly thick. It tapers down to a point. You now probe at the surface of the water with the point of that rod and find that the rod doesn't shrink. Rather, the pointed end simply disappears. You then pull that rod back toward you and find that the pointed end reappears. You are amazed.

*

In 1277 a council of the doctors of the Sorbonne, which took place under the presidency of the bishop of Paris, Etienne Tempier, condemned the notion that God is unable to move the whole universe in rectilinear motion because the universe would then leave behind a void. It was the denial of God's power that was condemned, not the reason given for denying that

power. Actually, Aristotelians and Thomists would not have given the reason stated by the council. They would say that motion of the whole universe is a meaningless one because outside the universe there is no place or void in which to move and no reference basis against which motion can be identified. Others would say that God could create a void in which the universe could move. The end result of the condemnation, according to Duhem, was that “the theologians of the Sorbonne traced out a path to the system of Copernicus” [3, 197].

This leads us to the question of the nature of void. Is it something real? If so, was it created or does it coexist alongside God? In Book IV of his *Physics*, Aristotle defines void as “place bereft of body” [1, p. 270]. He argued that there is no void outside a body, no void occupied by a body, and no void in a body; that is, there is no void at all [1, pp. 280-289]. When a body moves it takes occupancy of a place previously occupied by another body. St. Thomas used the conceptual framework of Aristotle but applied his own insights. Apparently he believed in the reality of void because we heard above from him that the void is not a simple negation but a privation. A privation is the absence of something from where it naturally should or could be. For example, the lack of the power of sight is a privation in a human person or a dog because sight belongs to the nature of those creatures. But the lack of power of sight in a tree is a negation because the power of sight does not belong to the nature of a tree. So it would seem then that, according to Aquinas, a void is the absence of a corporeal body from where one could be; that is, it is an empty place. Void is not a negation; that is, it is not simply nothingness. Thus Thomas ties in the nature of void with matter.

In his rejection of the possibility of a void Aristotle, according to some interpreters, argued that if there were motion in a void, a corporeal body would move instantaneously because there would be nothing to resist its motion. (Only a plenum would be able to offer resistance so that it would take a period of time for a body to travel from one place to another.) And since instantaneous motion was considered impossible, it followed that a void is also impossible.

Aquinas, contrary to that interpretation of Aristotle, defended the possibility of natural motion in a void (see [1, pp. 378–380] and [6, pp. 134–142]). He held that, in addition to the resistance of a material medium in which a body moves, there is also a inclination in a body to resist motion

contrary to its natural motion (violent motion) and an internal inertia of bodies that resisted being moved from one natural place to another. (Medieval scholars followed Aristotle in believing that the elements of fire, air, earth and water, had a natural inclination to move towards places in the universe reserved for those elements. Such motion is called natural motion. The natural motion of the fifth element, quintessence, of which the celestial bodies were supposed to be composed, was uniform circular motion about the earth.) So even in the absence of a material medium it would take a period of time for a body to move from one place to another because a body would provide its own resistance. Natural motion had a "natural velocity." More than three centuries later, Galileo, in opposition to the prevailing opinion, would follow Aquinas in upholding the possibility of motion in a void.

Pierre Duhem credits Aquinas with being the first to introduce the notion of mass into physics [3, pp. 379-380]. This comes about in Aquinas' discussions on falling bodies. Aquinas insisted that nature is not the efficient cause in the free fall of corporeal bodies; that is, the nature of a body is not the cause of its falling in the way that the nature of an animal is the cause of its movements. Rather, nature is an "active principle" in such free fall; that is, it is the nature of a corporeal body that makes it possible for it to fall. What is it in the nature of a corporeal body that makes it possible to fall? Aquinas answers that question in a lecture in his commentary on Aristotle's *Physics*:

> When the form, which the generator imparts, is removed from heavy and light things, a body with magnitude remains only in the understanding. But a body has resistance to a mover because it has magnitude and exists in an opposite site {opposite to where the movement would lead it}. No other resistance of celestial bodies to their movers can be understood. [3, p. 378]

Thus Aquinas abstracts from a material body the notion of "magnitude," what we today call "mass." Duhem sees this as a revolutionary accomplishment that Aquinas managed by distinguishing in thought, "on the one hand, a form, the motor force or gravity, and, on the other hand, prime matter given determined dimensions, not prime matter bare and

simple, but a quantified body occupying a certain location and resisting the force attempting to bring it elsewhere" [3, p. 379]. Duhem extols the magnitude of this achievement of St. Thomas. Referring to the passage above he states:

> Thomas's assertion, which we have just quoted, is extremely brief: let us not allow its brevity to make us misunderstand its importance. For the first time we have seen human reason distinguish two elements in a heavy body: the motive force, that is, in modern terms, the weight; and the moved thing, the *corpus quantum*, or as we say today, the mass. For the first time we have seen the notion of mass being introduced in mechanics, and being introduced as equivalent to what remains in a body when one has suppressed all forms in order to leave only the prime matter quantified by its determined dimensions. St. Thomas Aquinas's analysis, completing Ibn Bajja's, came to distinguish three notions in a falling body: the weight, the mass, and the resistance of the medium, about which physics will reason during the modern era. [3, p. 379]

In the same lecture cited above, Aquinas magically arrives at the notion of accelerated fall:

> The Commentator replies that the natural movement of light and heavy things requires this impediment from the medium so that there might be a resistance of the mobile body to the mover, at least from the medium. But it is better to say that all natural movement begins from a nonnatural place and tends to a natural place. Hence, until it reaches the natural place, it is not unsuitable if something unnatural to it is joined to it. For it gradually recedes from what is against its nature, and tends to what agrees with its nature. And because of this natural movement it is accelerated at the end. [3, p. 380]

The profundity of St. Thomas' cosmological insights will become more apparent as we proceed through this essay.

*

Let us return once again to our thought experiment. You try to explain your observations with the rods. Your experience with the tapered rod made it clear that the rods did not shrink. Either the ends of the rods were annihilated and recreated or there was something beyond the surface of the water that “absorbed” them. You dismiss the first alternative because you know that God gives his creatures persistence; He holds them in existence; He doesn’t toss them in and out of existence. Then something must have “absorbed” the ends of the rods without destroying them. You call that something “void.” You do not know what it is or if it is material; but you now know that it is part of your world. The void provided a place for the ends of the rods.

You next test to see if the void is made of matter. You do this by attaching one of the rubber balls to the end of one of the rods. You then push the rubber ball into the void and move it laterally with the rod to see whether the void offers any continual resistance to lateral motion of the ball, which you can sense through the rod. You find out that it doesn’t, so you are convinced that the void is not material.

You then reason that a rod is a material object with dimensionality. When one protruded through the surface of the water, it lent its dimensionality to the void it pierced. Before that the void was dimensionless nothingness, that is, it was no-thing; it was neither substance nor accident. Then you reason further. If the rod lent its three-dimensionality to the void then the whole earth must lend its three-dimensionality to the void, presuming that the earth is finite in size. That is a reasonable presumption because if the earth was infinite in size there would be no surface to its water. You then come to the final conclusion that the void is somehow part of the earth. You come to see that the void is a shadowlike extension of the earth’s existence because it provides other places in which the things of the earth can exist.

Enlightenment Notion of Space

The greatest change in cosmological thinking during the Enlightenment was the replacement of the concepts of place and void by the concept of immobile absolute empty space.

According to Max Jammer, the first major contribution to the concept of such a space was made in the sixth century A.D. by the philosopher Philoponus, also called John the Grammarian. Philoponus stated:

> Space is not the limiting surface of the surrounding body … it is a certain interval, measurable in three dimensions, incorporeal in its very nature and different from the body contained in it; it is pure dimensionality void of all corporeality; indeed, as far as matter is concerned, space and void are identical. [2, p. 56]

At first sight John seems to be simply formulating the belief of the Greek atomists, who preceded him, in contrast to the belief of Aristotle. The first century B.C. Greco-Roman poet Tius Lucretius Carus enshrined the philosophy of the Greek atomists in Latin verse in his poem *On the Nature of Things* [7]. In that poem he emphatically says that nothing exists but atoms and void.

John the Grammarian's position, however, appears to differ somewhat from that of the Greek atomists. Jammer explains Philoponus' identification of space and void:

> However this identification of space and void does not assume the existence of a void as such *"in actu."* The void, although a logical necessity, is always coexistent with matter. Void and body are two inseparable correlates, each of them requiring the existence of the other. As soon as one body leaves a certain part of space, another body "replaces" the first. A certain region of space can receive different bodies in succession without taking part in the motion of the occupying matter. Philoponus' phoronomy is completely analogous, as Duhem points out, to Aristotle's doctrine of substance and form, where one form is succeeded by another continuously, so that substance is never void of form. Just as matter successively receives one form

> after another, so a section of space may be occupied by one body after another, space itself remaining immobile. [2, p. 56]

Also, John's space does not have a favored direction, as does that of the Greek atomists. Lucretius speaks of atoms continually falling downward in infinite space. For Philoponus "down" is the direction toward the earth, which material bodies have an inherent tendency to reach; "down" is not a property of space itself.

It wasn't until the seventeenth century, more than a millennium after John the Grammarian proposed his notion of absolute space, that Isaac Newton gave the concept of absolute space a long-enduring place of honor in physics. Newton presented his conceptual scheme of space, time, matter and motion in his *Philosophiae naturalis principia mathematica* (1687), known simply as the *Principia*. In the beginning of the *Principia* Newton made clear his meaning of "absolute space" by comparing it with what he called "relative space":

> Absolute space in its own nature, without relation to anything external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute space; which our senses determine by its position to bodies; and which is commonly taken for immovable space; such is the dimension of a subterraneous, an aerial, or celestial space, determined by its position in respect to the earth. Absolute and relative spaces are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air, which relatively and in respect of the earth remains always the same, will at one time be one part of the absolute space into which the air passes; at another time it will be another part of the same, and so, absolutely understood, it will be continually changed. [2, pp. 99–100]

A little further on in the *Principia* Newton substitutes "sensible measures" for the parts of absolute space because absolute space itself is insensible and its parts indistinguishable:

> But because the parts of space cannot be seen, or distinguished from one another by our senses, therefore in their stead we use sensible measures of them. For from the positions and distances of things from any body as considered immovable, we define all places; and then with respect to such places, we estimate all motions, considering bodies transferred from some of those places to others. And so, instead of absolute places and motions, we use relative ones; and that without any inconvenience in common affairs. [2, p. 100]

Newton professed to eschew metaphysical reasoning in natural science. He said: “We are to admit no more causes of natural things than such are both true and sufficient to explain their appearances” [2, p. 101]. But he seeks to justify his introduction of absolute space with the famous statement: “But in philosophical disquisitions, we ought to abstract from our senses” [2, p. 101]. His notion of absolute space is purely metaphysical because absolute space is perceived only by the mind and not by the senses. The only things that we observe are relative places and motions measured against an arbitrary standard of rest. We may rightly ask whether absolute space is really a necessary abstraction or whether it is an invention, a “free creation of the human mind,” to use the words of Albert Einstein. Absolute space is not necessary for the validity of Newton’s three laws of motion and his law of gravity. Although he formulated them with absolute space in mind, they have only been experimentally verified in relative spaces, with the earth or some other celestial body as the standard of rest. Newton recognized that his laws were valid in a whole class of relative spaces that we today call “inertial spaces.” In a corollary of the *Principia* he says: “The motions of bodies included in a given space are the same among themselves, whether that space is at rest, or moves uniformly forwards in a right line without any circular motion” [2, p. 102]. The notions “rest,” “right line,” and “circular motion” can have an empirical meaning only with respect to corporeal bodies. In another corollary in the *Principia*, Newton acknowledges the necessity for an arbitrary corporeal standard of rest: “That the centre of this system of the world is immovable. This is acknowledged by all, while some contend that the earth, others that the sun, is fixed in the centre” [2, 203]. For Newton the center of the world is the center of mass of the bodies of the solar system. The center of mass of a

system of corporeal bodies can, in principle, be located inside one of the bodies or inside none of them; its location depends on their relative masses, sizes, and distances. Still, a center of mass is a standard of rest that ultimately depends on the existence of corporeal bodies. To say whether the center of mass of the solar system moves, we would have to observe whether it moves with respect to the stars. The notion of the center of mass of the whole universe moving through absolute space is empirically meaningless.

In modern physics, coordinate systems freestanding in absolute space are just as metaphysical as absolute space itself. Such coordinate systems and the absolute space (or space-time) they structure are fictional, but somehow they have proved quite useful. However, it will become clearer as we proceed in this book that too heavy a reliance on them has led physics up a blind alley.

Although Newton recognized that absolute space did not manifest itself kinematically, he believed that it did manifest itself dynamically. He believed that inertial effects, like the resistance of material bodies to a change in their speed and the concave surface of the water in a rotating bucket of water are caused by motion relative to absolute space. Thus uniform linear motion and accelerated motion have different manifestations in absolute space—the one relative, the other absolute. But Newton's notion that the center of the world is at rest allowed uniform linear motion to be referred to that point of rest, so that it too could be "absolutized." But uniform linear motion is then absolute by definition while accelerated motion is absolute by nature. To distinguish absolute motion from relative motion, Newton introduces the concept of "force" which is a "cause" that generates "true" motion:

> The causes by which true and relative motions are distinguished one from the other, are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered, but by some force impressed upon the body moved; but relative motion may be generated or altered without any force impressed upon the body. For it is sufficient only to impress some force on other bodies with which the former is compared, that by their giving way, that relation may be changed, in which

> the relative rest or motion of this other body did consist…. [2, p. 105]

Newton proceeds to admit the difficulty of distinguishing “true” motions of bodies from “apparent” motions, but he does not admit the impossibility of doing so:

> It is indeed a matter of great difficulty to discover, and effectually to distinguish, the true motions of particular bodies from the apparent; because the parts of that immovable space, in which those motions are performed, do by no means come under the observation of our senses. Yet the thing is not altogether desperate; for we have some arguments to guide us, partly from the apparent motions, which are the differences of the true motions; partly from the forces, which are the causes and effects of the true motions. [2, p. 105]

Jammer says that Newton’s forces, as presented above, are “metaphysical entities conceived anthropomorphically” and not functional entities [2, p. 106]. He says that Newton’s arguments “from causes” are based on traditional metaphysics. This is so even though Newton had strongly objected to the use of metaphysical arguments in natural science. Jammer says that there is a vicious circle in Newton’s reasoning concerning absolute motion and absolute force. He says that this can be seen by thinking of a world of moving masses in which no living organism [self-mover] existed. He says that “in such a world an absolute force can be determined, according to Newton, solely by the absolute motion of the body on which this force is exerted” [2, p. 106]. That is, the fact that there is absolute motion means that there must be a force which means there must be absolute motion, which means there must be a force, and so on—thus the circularity.

Newton’s notion of absolute space was criticized by three notable contemporaries: G. W. Leibniz and G. Berkeley (summaries of their criticisms are given in [8, pp. 97–106]) and C. Huygens (a summary of his criticism is given in [2, pp. 119–126]), none of whom accepted his dynamical arguments. Leibniz argued that space and time are not independent entities but depend on matter and material phenomena to give

them meaning. Berkeley argued that since absolute space in no way affects the senses, it is useless for distinguishing motions. He argued that all motion, including rotational motion, requires a corporeal frame of reference:

> If we suppose the other bodies were annihilated and, for example, a globe were to exist alone, no motion could be conceived in it; so necessary is it that another body should be given by whose situation the motion should be understood to be determined. The truth of this opinion will be very clearly seen if we shall have carried out thoroughly the supposed annihilation of all bodies, our own and that of others, except that solitary globe.
>
> Then let two globes be conceived to exist and nothing corporeal besides them. Let forces then be conceived to be applied in some way; whatever we may understand by the application of forces, a circular motion of the two globes round a common centre cannot be conceived by the imagination. Then let us suppose the sky of fixed stars is created; suddenly from the conception of the approach of the globes to different parts of that sky the motion will be conceived. [2, p. 109]

However, Berkley's argument was kinematical and does not adequately explain dynamic effects, such as the concave surface on a rotating pail of water. As we shall see later, the nineteen-century physicist, Ernst Mach, will give an explanation for that that avoids the notion of absolute space.

Leibniz, succinctly gives his conception of space, which is opposed to that of Newton, in a letter to S. Clarke, a disciple of Newton:

> As for my opinion, I have said more than once, that I hold space to be something merely relative, as time is; that I hold it to be an order of coexistences, as time is an order of successions. For space denotes, in terms of possibility, an order of things which exist at the same time, considered as existing together; without enquiring into their manner of existing. And when many things are seen together, one perceives that order of things among themselves. [8, pp. 97–98]

Leibniz further compares Newton’s attributing a real identity to absolute space to attributing a real identity to a genealogical tree. In a genealogical tree the individuals and their generational relationships are real things, but the tree they inhabit is only a mental construct. Likewise, corporeal bodies and their spatial and temporal relationships are real things, but the absolute space they inhabit is only a mental construct.

The arguments of Leibniz, like those of Berkeley, were kinematical. Leibniz, despite much effort, was unable to explain dynamic effects by relativity of motion. Jammer, however, credits him with coming close to Mach’s solution by attempting to reduce gravity to centrifugal force. Mach also connected gravity to centrifugal force but in the opposite way, by reducing centrifugal force to an effect of gravity.

Jammer credits the third contemporary critic of Newton’s absolute space, Christian Huygens, as the first physicist who defended both kinematic and dynamic relativity. His defense of dynamic relativity, however, was faulty. He explained the effects of centrifugal forces on a rotating disk as merely an indication of the relative motion of different parts of the disk. If one took as a reference system one rotating like the disk, then the motions of the parts of the disk would disappear. However, he neglected to observe that the pressure caused by the centrifugal forces and tending to pull the disk apart would still be present and would have to be explained.

The most outstanding critic of Newton’s concept of absolute space was the nineteenth-century physicist Ernst Mach. He was the first person to credibly defend dynamic relativity. Mach said that absolute space and absolute motion are “pure things of thought, pure mental constructs, that cannot be produced in experience” [10, p. 280]. Since there is no absolute motion, the motion of bodies is determined only in reference to other bodies. Thus, since there is only one system of the world, “the motions of the universe are the same whether we adopt the Ptolemaic or the Copernican mode of view. Both views are, indeed, equally *correct*; only the latter is more simple and more *practical*” [10, p. 283–284]. Mach held that inertial effects were not the result of the action of absolute space on a body; rather they were the combined effect of all the other material bodies in the universe on the body. Thus, for example, the earth bulges at the equator not because absolute space “pulls” on it; rather, the mass of cosmic bodies rotating around it “pulls” on it. And it does not matter if one thinks of the

cosmic bodies as rotating or the earth as rotating. Both views are equivalent. The inertial effects are produced by the *relative* rotation of the earth and the heavens. Mach wrote: “[I]t does not matter if we think of the earth as turning on its axis, or at rest while the fixed stars revolve around it…. The law of inertia must be so conceived that exactly the same thing results from the second supposition as from the first” [11, p. 10]. This idea, which has come to be known as *Mach’s principle*, implies that if there were no cosmic bodies there would be no inertial effects on the earth, for example, the earth would not bulge at the equator. It is not possible to test this directly because one cannot simply remove all the heavenly bodies. But, in principle, it can be confirmed indirectly by looking for inertial effects caused by the relative motions of terrestrial bodies. But such effects would be very small and very hard to measure. So far Mach’s principle has not been verified experimentally. Mach stated his principle in general terms, but he did not implement it. He said nothing about the nature of the interaction of material bodies with the rest of the universe. His principle is a simple concept, but its implementation required the rethinking of some physical concepts.

Theological considerations also were important to the seventeenth-century contestants on the issue of absolute space. Berkeley gave a cogent theological argument against absolute space. He said that space must be considered as relative “or else there is something beside God which is eternal, uncreated, infinite, indivisible, unmutable” [2, p. 112]. But Newton did not conceive space as coexisting with God. Rather he identified absolute space as an attribute of God. In the *Principia* he makes the statement:

> He [God] is not eternity and infinity, but eternal and infinite; he is not duration or space, but he endures and is present. He endures forever, and is everywhere present; and by existing always and everywhere, he constitutes duration and space. [2, p. 113]

Newton seems to have thought that God is spatially extended because He is able to move all the bodies in the universe. He is more able to move the bodies “within his boundless uniform Sensorium, and thereby to form and reform the Parts of the Universe, than we by our Will to move the Parts

of our own Bodies" [2, p. 113]. Leibniz argued that Newton's identification of the omnipresence of absolute space with the omnipresence of God implied that God is divisible because absolute space is divisible, a contention that was contested by Clarke. Leibniz interpreted Newton as conceiving space as an organ that God uses to perceive things. Therefore, continues Leibniz, it would follow that things do not depend altogether on God and were not produced by Him. But this argument rests on what may be a too literal interpretation of the word "sensorium." Newton seems to have used the word in an analogous sense.

Leibniz ridicules the notion that absolute space devoid of material bodies is still not really empty. This notion was a refuge of Newton supporters who wanted to retain the concept of place in space void of matter. He asks what it is filled with. Is it filled with extended spirits or other immaterial substances capable of extension, contraction and interpenetrability? Leibniz takes issue with their fantastic theology:

> Some have fancied, that Man in the State of Innocency, had also the Gift of Penetration; and that he became Solid, Opaque, and Impenetrable by his Fall. Is that not overthrowing our Notions of Things, to make God have Parts, to make Spirits have Extension? [2, p. 118]

Critics of Newton also pointed out that while absolute space acts on a material body, the body does not react on absolute space. This would violate a general physical principle, which is embodied in Newton's own third law, that every physical action is accompanied by a reaction that maintains balance in the universe.

Newton's conception of absolute space involved the rejection of the conceptual scheme of substance and accident. Traditional Catholic philosophy rejects the notion of absolute space because it is incompatible with the concept of quantity as understood by the scholastic masters. The prominent sixteenth-century scholastic theologian Francisco Suarez upheld the total dependence of space on matter:

> [Space is] a conceptual entity, not, however, formed at will like chimeras, but extracted from bodies, which by their extension

> are capable of constituting real spaces (*Metaphysical Disputations* 51)
> .

Quantity is the principle of individuation. Among material substances there are many species and many individuals of the same species. The individuals are not individuated by nature (as are spiritual creatures) but by matter itself, prime matter determined by the accident of quantity. Matter so individuated is called *signate matter* or *matter marked by quantity*. Scholastic philosophy holds that absolute space is only a conceptual entity that is abstracted from signate matter. Extension is an accident of physical bodies that the mind perceives and from which the mind constructs absolute space. Extension is a necessary concomitant to quantity, and every quantity is the quantity of something. But absolute space is pure extension, which means it is quantity without a subject. In other words, absolute space is quantified nothingness, which is a contradiction in terms. It is a contradiction in reality; but it is not, however, a contradiction in the mind because it is a mental abstraction. It is an accident without a subject. It is like the shape of a statue without any material holding that shape; such can exist only in the mind and not in reality. Further, absolute space is not a privation, as St. Thomas Aquinas identified void, because privation implies means the absence of something where it can be. But absolute space is conceived without reference to anything but itself.

Enlightenment thinkers conceived of space as an attribute of God or as coexistent with God. But they do not seem to have considered the idea of space as a creation of God. If they did, their thinking would have led them to a more realistic vision of the universe. We saw above that St. Thomas Aquinas clearly taught that space (void) was created in the beginning of the world along with matter. When God created the earth as the first material body, He created the three-dimensional space it occupies. Space, like time, is an epiphenomenon of material creation. With the creation of the celestial bodies God created void, which separates and helps distinguish the heavenly bodies from each other and the earth. Void has no meaning except in reference to the material objects it surrounds. Matter lends its dimensionality to void. Job 26:7 confirms that the three-dimensionality of void is extrapolated from three-dimensional matter:

He stretches out the north over the void, and hangs the earth upon nothing.

Before creation there was no infinite three-dimensional absolute space into which God injected matter. The mental image of an empty three-dimensional absolute space existing before creation is abstracted by our minds from a world filled with matter. Before creation there was nothing but God. And “nothing” does not mean “three-dimensional emptiness.” It means “no thing.”

Newton’s concept of absolute space provided an amazingly successful basis for the explanation of the observed inertial behavior of material bodies and thus led to the development of classical mechanics despite the problems concerning its hypostatization. The successes of classical mechanics overshadowed objections against absolute space until the development of modern physics in the twentieth century, when they once again came to the fore. Among scientists who developed classical mechanics from Newton’s laws, like, for example, Lagrange, Laplace and Poisson, there was little interest in the reality of absolute space. They just accepted it as a working hypothesis. The great formulator of classical electromagnetic theory, James Clerk Maxwell, succinctly presented the paradox that the notion of absolute space introduced into physics. He said: “All our knowledge of space and time is essentially relative” [9, p. 12]. But he adds the following footnote to that statement: “The position seems to be that our knowledge is relative, but needs definite space and time as a reference for its coherent expression.” Absolute space is the phantasm of disembodied quantity that haunts classical mechanics.

Medieval and Enlightenment Notions of Time

The history of opinions about time is long and tortuous. In his cosmological dialogue *Timaeus* Plato calls time a "moving image of eternity" [12, p. 1167]. In his *Physics* Aristotle said that time is the measure of movement and movement is the measure of time; movement and time define each other [1, p. 294]. The Greek atomists said that time has no separate existence; things in motion cause time [7, p. 33]. Here we are only concerned with differences in the conception of time between the scholastic doctors and enlightenment thinkers.

The scholastic doctors, following Scripture under the guidance of the Church, rightly believed that time was created by God in the beginning. The first Christian writer to write extensively on time and whose views on time carried great weight with the scholastics was St. Augustine. Augustine explores the subject of time in Book XI of his *Confessions*. He declares that it is a difficult subject: "What then is time? If no one asks me, I know; if I want to explain it to someone who asks me, I do not know. I can state with confidence, however, that this much I do know: if nothing passed away there would be no past time; if there was nothing on its way there would be no future time; and if nothing existed there would be no present time" [13, pp. 295–296]. Thus he denies the self-existence of time. In Chapter 5 of Book XI of the *City of God* Augustine affirmed his belief that before the creation of the world there was no time: "It is idle for men to imagine previous ages of God's inactivity, since there is no time before the world began" [14, p. 435]. St. Augustine refuted the idea that time existed before the creation of the world because it makes God live in time and the creation of the world look like a thought that suddenly occurred to Him, thus making Him changeable and not eternal. In Chapter 6 of Book XI of the *City of God* he affirms his belief that "without motion and change there is no time" [14, p. 435]. He goes on to reaffirm his belief in the creation of time: "The world was not created in time but with time" [14, p. 436]. St. Thomas Aquinas concurs with Augustine saying: "Things are said to be created in the beginning of time, not as if the beginning of time were a measure of creation, but because together with time heaven and earth were created" [5, Part I, Q. 46, A.3, Reply Obj. 1]. Lateran Council IV and Vatican Council I affirmed the creation of time. They both decreed that God "from the

beginning of time created each creature from nothing…” [15, nos. 428, 1783].

Catholic philosophy, following Aristotle, Augustine and Aquinas, associates time with movement. The *Catholic Encyclopedia* (1914) article on time states: “In fact, say the Scholastics, we never perceive time apart from movement, and all our measures of our temporal duration are borrowed from local movement, particularly the apparent movement of the heavens” [16, article entitled “Time”].

The thinking of enlightenment philosophers on time, like their thinking on space, deviated from that of the scholastic masters. Newton, in the same scholium in his *Principia* that he presents his notions of absolute and relative space, also presents his notions of absolute and relative time. He describes them as follows:

> Absolute, true, and mathematical time, of itself and from its own nature, flows equably without relation to anything external, and by another name is called ‘duration’; relative, apparent, and common time is some sensible and external (whether accurate or unequable) measure of duration by means of motion, which is commonly used instead of true time, such as an hour, a day, a month, a year. [17, p. 17]

The notion that absolute time “flows” is a very peculiar one indeed. If it is intended as a metaphor, it is a very misleading one. The flow-of-time concept is circular because the concept *flow* already includes time, measured time. Does time flow at x seconds per second? Or perhaps there is a hierarchy of time, that is, time flows at x seconds per supersecond. But do superseconds also flow, perhaps at y superseconds per second? But now we are in a vicious circle. Then maybe superseconds flow at y superseconds per supersupersecond. We are now in an infinite regress. So where do we go with the notion of the flow of absolute time?

Newton sees absolute time as the standard for calibrating relative time, but does not show how such calibration can be done.

> Absolute time, in astronomy, is distinguished from relative by the equation or correction of the apparent time. For the natural days are truly unequal, though they are commonly considered

> as equal and used for a measure of time; astronomers correct this inequality that they may measure the celestial motions by a more accurate time. It may be that there is no such thing as equable motion whereby time may be accurately measured. All motions may be accelerated and retarded, but the flowing of actual time is not liable to any change. The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all; and therefore this duration ought to be distinguished from what are only sensible measures thereof and from which we deduce it, by means of the astronomical equation. The necessity of this equation, for determining the times of a phenomenon, is evinced as well from the experiments on the pendulum clock as by eclipses of the satellites of Jupiter. [17, p. 19]

Newton seems to have said that the very fact of something existing gives rise to absolute time, even if no change takes place in the existing thing. Its "perseverance" in existence causes absolute time. But how is time in that way measured, or even defined? God perseveres in existence, but He is unchanging and does not live in time but transcends time. The Scholastics understood that, but apparently Newton did not.

The only way to set up a measurable standard of time is to use a periodic physical phenomenon. That physical phenomenon can be compared with another periodic physical phenomenon to see if their periodicities synchronize. If they do, then the standard is reinforced. If they don't, then one of the phenomena is accepted as the standard and the other is "corrected" to agree with it. In the passage above Newton said that "it may be that there is no such thing as equable motion whereby time may be accurately measured." He would have been more on target if he removed the words "it may be that." There is no such thing as "equable motion" because there is no way to physically define it. It cannot be physically defined because there is no way to make a comparison with something as abstract as absolute time. Absolute time, like absolute space, is disembodied quantity. It exists only in the mind but not in reality.

Newton proposes that the "astronomical equation," which is presumably his law of gravitational attraction, is a means for determining absolute time. Mathematical equations simply describe physical phenomena. The better an

equation describes an observed phenomenon, the more useful it is. But an equation does not hypostatize the quantities it employs. So the fact that the notion of absolute time is used in an equation does not mean that such exists. The notion itself is just a convenient mental construct that somehow gives answers in agreement with observations. Physical science employs a number of such constructs, for example, points and imaginary numbers.

Enlightenment opinions about time varied from the extreme objective view of Newton to the extreme subjective view of Immanuel Kant, who saw time as solely a creation of the human mind. Such opinions often departed widely from the commonsensical viewpoint of medieval Christendom. The majority of the medieval schoolmen conceived time as partly objective and partly subjective. Objectively, motion is something real; it is an object of experience. Subjectively, the mind divides motion into before and after and perceives time as the measure of movement according to before and after [18]. Time can be thought of as that which, to a finite mind, makes present various potentialities in a subject. Leibniz' view of time was perhaps the closest to the medieval view since he held time as an order of successions.

God gave us natural standards of rest and time. He made the earth the standard of rest. For time He gave us natural rhythms rather than a single defined standard. The most basic is the daily rhythm determined by the stars, which gives us day and night. Following that He gave us the annual rhythm determined by the sun, which gives us the cycle of seasons. Finally the monthly rhythm determined by the moon, which gives us the tides and graduates the seasons.

CHAPTER TWO: SACRED SCRIPTURE AND THE EARTH AS THE CENTER OF THE COSMOS

The Creation of Heaven and Earth

The first three verses of Genesis relate the absolute beginning of the universe:

> *In the beginning God created heaven and earth. And the earth was void and empty, and darkness was upon the face of the deep. And the spirit of God moved over the waters. And God said: Be light made. And light was made.* [Douay-Rheims]

The Septuagint says that the earth was *"invisible and shapeless."*

The Jewish Biblical Society version translates these three verses as a single sentence that highlights the state of the universe when light was created:

> *When God began to create heaven and earth—the earth being unformed and void, with darkness over the surface of the deep and a wind from God sweeping over the water—God said, "Let there be light"; and there was light.*

The first material object created was the earth. Although *"heaven"* is mentioned first, it does not necessarily mean that it was the first thing created. The first verse may simply be an introductory summary, an abstract, of what follows. But if it does indeed relate the very first act of God during Creation Week, then the Hebrew word *shamayim*, translated "heaven," in a physical sense could mean the void surrounding the earth (the heavenly bodies were not created until the fourth day). The void is not something that exists in itself; for then it would be coeternal with God, that is, it would have being that did not come from God, who is the source of all being. Nor is it an attribute of God because that would limit God by making Him somehow three-dimensional. Nor was the void created alongside matter, with a separate and independent existence, because then it would be a substance without matter and form, which is senseless. Rather, the void is connected with matter, as St. Thomas Aquinas and others correctly observed. So it came into existence with the earth. Scripture may even have identified it with the earth in the second verse. Perhaps the earth being *"void"* means that the void surrounding the earth was actually part of it.

This makes sense because the void takes its meaning and its dimensionality from the earth. The earth being *"empty"* or *"unformed"* means that the distinctions of the first three days and the adornments of the second three days had not yet been made.

The word *"heaven"* in the first verse might instead mean the matter of which the celestial bodies were made. St. Augustine, St. Basil, St. Gregory of Nyssa, St Ambrose and other Fathers believed that the raw material of all corporeal bodies was created at the very beginning. This is how Augustine expressed it in *Genesis Defended against the Manicheans*

:

> So then, that formless material which God made from nothing was first called "heaven and earth" where it is said: *"In the beginning God made heaven and earth,"* not because that is what it already was, but because it was able to be that—the making of heaven, you see, is described a little later on. It's as if, when we examine the seed of a tree, we were to say that the roots are there, and the trunk and the branches and the fruit and the leaves, not because they are in fact already there, but because they are going to come from there. That's how it says, *"In the beginning God made heaven and earth,"* as a kind of seed of heaven and earth, when the material of heaven and earth was still all unsorted; but because it was quite certain that heaven and earth were going to come from there, the material itself was already called heaven and earth. [19, pp. 45–46]

Augustine also professes that belief in his *Confessions* (Book XII, no. 15):

> [T]hese two things I have mentioned, heaven and earth, were what you made before all days, in the beginning. *"The earth was invisible and unorganized, and darkness loured over the abyss."* These words suggest formlessness, so that the truth may gradually lay hold on the minds of those who are unable to think of an absolute privation of all form without pushing the idea to nothingness. From this formlessness were to be made another heaven and the visible, organized earth, and the beauty of fully formed water, and whatever else would thereafter

> constitute our world. In the making of this world a succession of days is mentioned, because the nature of these things is such that temporal succession is needed in their case to bring about ordered modifications of motion or form. [13, p. 320]

The formless matter that Augustine perceived was not what we would call "amorphous matter", that is, matter that has a form but a form that is not well-defined. That notion he explicitly rejected (Book XII, no. 6). Neither did he perceive it as matter that has a continual succession of such forms. He also rejected the notion of formless matter as "something midway between form and nothingness" (Book XII, no. 6). He goes on to consider the mutability of corporeal bodies and begins to suspect that the "transition [of a body] from one form to another involves passing through formlessness, rather than through absolute non-being."

It should be interjected here that in the *Confessions* Augustine interpreted the *"heaven"* of the first day of creation as the spiritual creation, that is, the creation of the angels (Book XII, nos. 2–16, 23). This is the *"heaven of heaven"* of Psalm 113 (115):

> *The heaven of heaven is the Lord's: but the earth he has given to the children of men.* [Douay-Rheims: Ps 113:16]

The earth of the first day of creation was formless matter, from which apparently both the "visible, organized" earth and "another" heaven were made (Book XII, no. 16). The second heaven is the physical *"heaven"* of the second day of creation.

Augustine perceived formless matter as being in a state of quasi-eternity, that is, in a timeless state:

> … the invisible and unorganized earth, where also there was no succession of time, for succession implies that one thing is followed by another, and where there is no form there cannot be any question of one thing, then another. [13, p. 320]

Augustine's formless matter comes close to what is called in scholastic philosophy *prime matter*. Prime matter is pure potentiality. It has the potential to be any material thing. However, it exists separately in the mind

only. In the world of real things it is always united to substantial form. In *The Literal Meaning of Genesis* Augustine asserts that formless matter is prior to formed matter as a source but is not prior in time. He said: “God did not first make formless material and later on form it, on second thoughts as it were, into every kind of nature; no, he created formed and fashioned material” [19, p. 181]. In this Augustine differed from other Fathers who believed that unformed (amorphous) matter was created on the first day and was “formed and fashioned” on the following five days.

St. Thomas Aquinas believed that the original condition of matter was an undefined mixture of elements waiting to be organized. St. Bonaventure’s view was closer to that of Augustine than to that of Aquinas. He saw the original condition of matter, to use modern terminology, as pure energy waiting to be transformed.

The view that all the matter of the universe was created at the very beginning, in the light of Genesis 1:1-3, 14, could mean that the earth originally contained all the matter in the universe, from which God made the heavenly bodies on the fourth day. In that case earth would be the mother of the universe. Or, it could mean that earth was the first thing formed from the “shapeless matter,” which would also make it a special place in the universe.

However, it is not an issue whether God created all the matter in the universe at the very beginning of Creation Week or if He created the matter along with the forms of creatures at various times during Creation Week. The important point Genesis makes is that God made the earth first and built the rest of the universe around it and for it because earth was to be the home of His masterpiece, man.

There is a question that causes wonder in some readers of Genesis 1:3. It concerns the source of the light that God created on the first day. Where did the light come from if the sun and stars were not yet made? A possible source for the light could have been chemical and nuclear reactions in the raw matter of earth itself. But according to modern physics a source really isn’t needed. Light is not tethered to a source. Once a photon of light leaves its source it is free and has an existence of its own. So modern physics has no problem with the idea that God created light without a source. And neither did St. Thomas Aquinas have a problem with it. He stated:

> I answer, then, with Dionysius (*The Divine Names*, Book IV), that the light was the sun's light, formless as yet, being already the solar substance, and possessing illuminative power in a general way, to which was afterwards added the special and determinative power required to produce determinate effects. [5, Part I, Q. 67, A. 4, Reply Obj. 2]

Further, it will be explained in the next article why there is no problem with the fact that God set up the standard of a natural day independent of the sun, as related in verses 4–5.

The Formation of Heaven and Earth

Verses 1:6–10 of Genesis relate God’s work on the second and third days, during which heaven and earth were given their forms. Verses 6–8 relate the formation of heaven with the creation of the firmament on the second day:

> *And God said: Let there be a firmament made amidst the waters; and let it divide the waters from the waters. And God made a firmament, and divided the waters that were under the firmament from those that were above the firmament. And it was so. And God called the firmament Heaven. And the evening and morning were the second day.* [Douay-Rheims]

The Jewish Biblical Society version translates the verses using the words *“expanse”* and *“Sky,”* rather than *“firmament”* and *“Heaven.”*

> *God said, “Let there be an expanse in the midst of the water, that it may separate water from water.” God made the expanse, and it separated the water which was below the expanse from the water which was above the expanse. And it was so. God called the expanse Sky. And there was evening and there was morning, a second day.*

There is no special word in Hebrew for what we call the *world* or the *universe* or what the Greeks called *cosmos.* Instead, Genesis uses more concrete terms like *heaven*, *earth*, *waters*, *land* and *sea*. The Hebrew word *shamayim* is translated “heaven,” in the Douay-Rheims version. But it does not mean God’s special abode except in a metaphorical sense, as St. Thomas Aquinas points out [5, Part I, Q. 68, A. 4]. Rather, it seems that it corresponds to our word “space,” the abode of the heavenly bodies. It is sometimes translated “sky,” as in the Jewish Biblical Society version. In verse 1:8 God names the *rakia* that He called into being *shamayim.* The Hebrew word *rakia* is traditionally translated “firmament,” “dome,” or “vault.” This is unfortunate because it misleads modern readers. It gives the impression that the Hebrews believed that the earth was surrounded by a solid dome. The Hebrew word emphasizes strength and fixity, but it does not imply solidity. The most accurate translation is probably “expanse.”

More than one expanse is not excluded by the text. There may be one expanse below the separated waters and another above, the one above being the *“heaven”* mentioned in the first verse.

St. Thomas saw two interpretations for *“firmament.”* The first is the “starry firmament.” “Another possible explanation is to understand by the firmament that was made on the second day, not that in which the stars are set, but the part of the atmosphere where the clouds are collected, and which has received the name ‘firmament’ from the firmness and density of the air” [5, Part I, Q. 68, A. 1].

Genesis locates water in three places in the universe—above the expanse (1:7; 7:11), on the earth (1:7, 9), and under the earth (7:11). The waters above the expanse cannot be reckoned as clouds and vapor such as we have in our atmosphere. Clouds and vapor can hardly account for the huge mass of water that was separated from the deep. The text does not say what configuration the waters above the expanse took; it remains a mystery. Perhaps the moon was once covered by water, or maybe there were other moons that were composed of water. It may have been that such moons supplied the water that flowed through the *“flood gates of heaven”* (Gn 7:11) contributing to the Great Flood.

St. Thomas Aquinas held that the waters are material entities and not spiritual entities, as some authors asserted; but he was not definite about their material nature:

> We must hold, then, these waters to be material, but their exact nature will be differently defined according as opinions on the firmament differ. For if by the firmament we understand the starry heaven, and as being of the nature of the four elements, for the same reason it may be believed that the waters above the heaven are of the same nature as the elemental waters. But if by the firmament we understand the starry heaven, not, however, as being of the nature of the four elements then the waters above the firmament will not be of the same nature as the elemental waters, but just as, according to Strabus, one heaven is called empyrean, that is, fiery, solely on account of its splendor: so this other heaven will be called aqueous solely on account of its transparence; and this heaven is above the starry heaven. Again, if the firmament is held to be of other nature

> than the elements, it may still be said to divide the waters, if we understand by water not the element but formless matter. Augustine, in fact, says that whatever divides bodies from bodies can be said to divide waters from waters (*Genesis Defended Against the Manicheans*, Book I, 5, 7).
>
> If, however, we understand by the firmament that part of the air in which the clouds are collected, then the waters above the firmament must rather be the vapors resolved from the waters which are raised above a part of the atmosphere, and from which the rain falls. But to say, as some writers alluded to by Augustine, that waters resolved into vapor may be lifted above the starry heaven, is a mere absurdity (*The Literal Interpretation of Genesis*, Book II, Chapter 4). The solid nature of the firmament, the intervening region of fire, wherein all vapor must be consumed, the tendency in light and rarefied bodies to drift to one spot beneath the vault of the moon, as well as the fact that vapors are perceived not to rise even to the tops of the higher mountains, all go to show the impossibility of this. Nor is it less absurd to say, in support of this opinion, that bodies may be rarefied infinitely, since natural bodies cannot be infinitely rarefied or divided, but up to a certain point only [5, Part I, Q. 68, A. 2.].

It may be that the water above the firmament was the raw material that God used to create the heavenly bodies on the fourth day. It may actually have been real water that God transformed to make the heavenly bodies, just as Christ transformed water into wine at Cana.

St. Augustine in *Genesis Defended against the Manicheans* saw water as possibly being a name for the formless matter:

> He also called the very same material [formless material] water, over which the Spirit of God was borne as the will of the craftsman is borne over things to be crafted. The reason though it is not absurd to call this material “water” is that everything that is borne on the earth, whether animals or trees or grasses and anything else of that sort, starts off by being formed and nourished from moisture. [19, p. 46]

In *The Literal Meaning of Genesis* he says essentially the same thing: [Scripture] “may have wanted to call by the name of ‘water’ the whole basic material of the bodily creation” [19, p. 172]. Augustine points out in his *Unfinished Literal Commentary on Genesis* [19, pp. 120–122] and in *The Literal Meaning of Genesis* [19, p. 180] that nowhere in the creation account is it said that God made the water. Genesis just presumes its existence. This strengthens the argument that water is simply a name for the formless matter [or *is* the formless matter] from which heaven and earth were made.

Verses 1:9–10 relate the formation of the earth on the third day:

> *God also said: Let the waters that are under the heaven be gathered together into one place, and let the dry land appear. And it was done. And God called the dry land Earth; and the gathering together of the waters he called Seas. And God saw that it was good.* [Douay-Rheims]

In *Genesis Defended against the Manicheans* Augustine explains this passage as follows:

> But it has already been said about the earlier verse that the name of waters was given to that basic material over which the Spirit of God was being borne, from which God was going to form everything. Now however, when it says, *“Let the water which is under the heavens be collected into one collection,”* it means that that bodily material is being formed into the specific nature and appearance which these visible waters have. The very collecting together into one, you see, is the formation of these waters which we can see and touch. Every form, after all, is compressed into fitting the standard of unity.
>
> As for its saying, *“Let the dry land appear,”* what else is it to be understood as saying, but that that material is to receive the visible form which this earth has that we can see and touch? So that the earth was earlier on being called invisible and shapeless [according to the Septuagint] meant that the basic material was being named as unsorted and dark; and by the

> water over which the Spirit of God was being borne, another name was given to this basic material. Now, however, this water and earth are being formed from that material which was earlier on called by their names, before it received these forms which we can now see. [19, p. 50]

In the *Unfinished Commentary on Genesis*, Augustine says essentially the same thing, adding that the formation of the land and sea was in their naming:

> *"And God called the dry land earth, and the collection of water he called sea."* This matter of names is still with us; not every piece of water is sea or everything dry is earth. So exactly what water and what dry land was meant had to be distinguished by names. But we can still not unreasonably take it that it was God's naming of them which distinguished and formed these elements. [19, p. 134]

We must recall at this point that Augustine believed that everything was created at once, either in actuality or in potency, with both matter and form. He explains his position on that issue quite clearly in his *Unfinished Literal Commentary on Genesis*:

> So then, perhaps it is said *"And there was made evening and there was made morning, one day"* in the sort of way in which one foresees that something can or ought to be done, and not in the way in which it actually is done in a certain stretch of time. After all, it was in its essential nature that God's creative work was observed in the Holy Spirit by the author who said, *"The one who abides forever created all things simultaneously"* (Sir 18:1). But in this book of Genesis the story of the things made by God most appropriately sets them out as it were through intervals of time; by this arrangement of the account in an orderly sequence, the divine plan itself, which cannot be directly and timelessly contemplated by our weaker intellects, is presented, so to say, as a spectacle for our very eyes to gaze on. [19, pp. 130–131]

For Augustine formless matter exists in the mind only and not in actuality. The division of God's labors in shaping formless matter over time is a literary device to make the story of creation understandable.

Augustine's viewpoint notwithstanding, the understanding of water as being the formless matter of Genesis 1 still makes sense if it is assumed that the whole earth had the form of *real* pure water and that God transformed some of the water into land and gathered the rest into the seas.

The primal earth might also be thought of as being totally murky water, with the elements of the earth mixed in with it. God then separated the earthy components to form land. Or, primal earth might have been an amorphous mixture of elements waiting to be separated and combined into substances, a la St. Thomas Aquinas, being called water because of its fluid nature. The Hebrew word *mayim* translated "water" is also used figuratively for other fluids.

St. Gregory of Nyssa used an analogy that may be applied here in a more direct way. He held that God created everything simultaneously; but He created them in a confused state, that is, indistinctly. Then "the work of nature" distinguished them according to an order fixed by God. He gives as an analogy a mixture of oil, water and quicksilver. Mixed together they are indistinguishable. But after a while the quicksilver sinks to the bottom, the water settles on it, and the oil rises to the top. The three liquids are distinct substances, but this becomes apparent only after gravity is allowed to do its work. His analogy can be applied to verses 9–10 in this way: The original unformed earth was a fluid mixture of water and other substances. God separated the other substances from the water, not necessarily by natural means, to form water and dry land.

Verses 1:14–18 relate the creation of the heavenly bodies on the fourth day of Creation:

> *And God said: Let there be lights made in the firmament of heaven, to divide the day and the night, and let them be for signs, and for seasons, and for days and years: To shine in the firmament of heaven, and to give light upon the earth. And it was so done. And God made two great lights: a greater light to rule the day; and a lesser light to rule the night: and the stars. And he set them in the firmament of heaven to shine upon the*

> *earth. And to rule the day and the night, and to divide the light and the darkness. And God saw that it was good.* [Douay-Rheims]

The heavenly bodies may have been created completely, matter and form, on the fourth day; or they may have been made from the raw material created on the first day. Perhaps God made them from the waters that were raised above the expanse. Or, perhaps the expanse was a plenum that contained the raw materials for the cosmic bodies.

It has been a cause of wonder that day and night were created before the sun and the moon. Some readers of Genesis can't understand how there was a first day before the sun was created and so dismiss the creation account as myth or allegory. But verse 16 says that God created the sun and the moon to *"rule"* the day and the night, not to *determine* them. This means that the periods of day and night ontologically precede the sun and moon. The sun and moon were created to regulate periods of time that had already been determined. St. John Chrysostom expressed this way: "He created the sun on the fourth day lest you think that it is the cause of the day" [20, p. 16].

The Earth as the Center of Rest

Genesis 1 makes it clear that God made the earth first and built the rest of the universe around it. Scripture elsewhere makes it clear that God also defined the earth to be the standard of rest in the universe. This is made clear in Psalms 92 (93):

> *For He hath established the world which shall not be moved.* [Ps 92:1 (Douay-Rheims)]

The Hebrew word *kun* translated "established" has a variety of applications, including "ordain," "appoint." The Hebrew word *tebel* translated "world" means the earth and not the universe.

The stationary earth standard is confirmed by Psalms 103 (104):

> *Who hast founded the earth upon its own bases; it shall not be moved for ever and ever.* [Ps 103:5 (Douay-Rheims)]

It cannot be said that the earth is absolutely at rest because that means that it would be at rest with respect to something else that is absolutely at rest. What would be that something be other than absolute space? But it was shown above that there is no absolute space. So a standard of rest must be defined; it is not given by nature. God defined it to be the earth.

Sacred Scripture applies the stationary earth standard concretely in describing two famous miraculous events that occurred in the history of Israel. Both attested to the movement of the sun in the heavens.. The first event is "Joshua's long day." It is recorded in Joshua 10: 12–14:

> *Then Josue spoke to the Lord, in the day that he delivered the Amorrhite in the sight of the children of Israel, and he said before them: Move not, O sun, toward Gabaon, nor thou, O moon, toward the valley of Ajalon. And the sun and the moon stood still, till the people revenged themselves of their enemies. Is not this written in the book of the just? So the sun stood still in the midst of heaven, and hasted not to go down the space of one day. There was not before nor after so long a day, the Lord*

> *obeying the voice of a man, and fighting for Israel.* [Douay-Rheims]

Joshua’s long day was observed around the world, as indicated in the folklore of various nations.

The second event is “Hezekiah’s sign.” It is recorded in Isaiah 38:7–8:

> *And this shall be a sign to thee from the Lord, that the Lord will do this word which he hath spoken: Behold I will bring again the shadow of the lines, by which it is now gone down in the sun dial of Achaz with the sun, ten lines backward. And the sun returned ten lines by the degrees by which it was gone down.* [Douay-Rheims]

This event involving the backward movement of the sun is also recalled in 4 Kgs (2Kgs) 20:8-11 and 2 Par (2 Chr) 32:24.

In these depictions Sacred Scripture is doing more than simply describing the events as they appeared to observers on earth. It is making the profound implication that the earth is the center of rest in the universe. If there were such a thing as absolute rest in the universe, and if the sun were at absolute rest with the earth moving around it (as per the Copernican system), then the Sacred Author would be deceiving us in these verses, which is unthinkable.

The essential misunderstanding in the Galileo affair was the mistaken notion that there is a natural condition of absolute rest. In both the systems of Ptolemy and Copernicus it was presumed that there is a place of absolute rest. The major difference between them was the location of that place.

The earth is said to be at the center of the universe because it is a place in the universe with special properties, just as geometric centers and centers of mass are places with special mathematical and physical properties. God created the earth first, built the rest of the universe around it, defined it as the center of rest, and made it the home of man, who is a unique union of matter and spirit. The centrality of earth in the universe might also be expressed geometrically and/or physically, but it need not be so to be in accord with Scripture and Tradition.

The Notion of Absolute Rest: Historical Summary

The medieval schoolmen saw the universe as a finite, bounded plenum or quasiplenum with the earth at rest in the center with the heavenly spheres rotating about it. They had a notion of void but no notion of absolute space in the Newtonian sense. Their notion of the earth being at rest meant that the heavens were moved around the earth by some efficient cause distinct from the spheres. And the earth was not moved with respect to the heavens by any such efficient cause. Thus they had a notion of absolute rest. This cosmology colored their interpretation of the Scriptural passages that relate to the stability of the earth.

Newtonian physics also has a notion of absolute rest because it has a notion of absolute space to which all motion is referred. Newton, however, following Copernicus, set the sun at absolute rest with the earth moving around it, its motion being caused by its inertia, which was given to it by God in the beginning [see 17, pp. 47–49].

The modern view, following Einstein, sees the universe as an unbounded three-dimensional absolute space with a geometrical structure determined by the masses that occupy it. The cosmological principle, which states that the universe looks pretty much the same from wherever in it you view it, makes the notion of rest relative. Any body in the universe can be defined to be at rest.

Without subscribing to Einsteinian cosmology and the cosmological principle, one can still interpret rest as relative. The passages in Scripture referring to the stability of the earth can be interpreted to mean that the earth is at rest because God defined it to be so. He made the earth the standard of rest in the universe because it was the first body created and is the home of man. This requires rejection of the notion of absolute space because that notion contains within it the notions of absolute rest and absolute motion.

Medieval Earth-Centered Cosmology and its Decline

Sacred Scripture makes it clear that man and his home, earth, are the focus of the universe. The centrality of man was expressed geometrically in the Christian medieval cosmos by having the earth at rest with the sun and the heavens moving around it, using a model that came from the Greeks but was in harmony with Scripture. In the medieval cosmos there was order and hierarchy. God encompassed all and man, His steward, was at the center. Love was the great mover. The medieval universe had a rational structure with a purposeful place for everything. Philosopher of science E. A. Burtt nicely summarizes the medieval Christian vision:

> For the Middle Ages man was in every sense the center of the universe. The whole world of nature was believed to be teleologically subordinate to him and his eternal destiny. Toward this conviction the two great movements which became united in the medieval synthesis, Greek philosophy and Judeo-Christian theology, had irresistibly led. The prevailing world-view of the period was marked by a deep and persistent assurance that man, with his hopes and ideals, was the all-important, even controlling fact in the universe. [21, p. 18]

Medieval Catholic astronomy testified to the deeply-engrained belief that man is the masterpiece and center of creation. His good is the end of all creation. Nature exists for his use, to help him attain his end, which is to serve God here on earth and to spend eternal life with Him in heaven.

Nicholaus Copernicus disturbed that worldview by having the earth move, and the theological confusion caused by Galileo’s aggressive advocacy of Copernicus’ cosmology had the sad effect of clouding the truth of man’s centrality and shattering the medieval vision. This decline was further advanced by enlightenment ideology, which produced a cosmology with man removed from the center of creation.

Burtt contrasts the drab view of man in the universe advanced by Galileo and developed by enlightenment thinkers with the bright picture of the medievals:

> Note, however the tremendous contrast between this view of man and his place in the universe, and that of the medieval tradition. The scholastic scientist looked out upon the world of nature and it appeared to him a quite sociable and human world. It was finite in extent. It was made to serve his needs. It was clearly and fully intelligible, being immediately present to the rational powers of his mind; it was composed fundamentally of, and was intelligible through, those qualities which were most vivid and intense and his own immediate experience—colour, sound, beauty, joy, heat, cold, fragrance, and its plasticity to purpose and ideal. Now the world is an infinite and monotonous mathematical machine.… It was simply an incalculable change in the viewpoint of the world held by intelligent opinion in Europe. [21, pp. 123-124]

The modern view, held by many scientists and scholars today, was clearly expressed by Bertrand Russell in *A Free Man's Worship (Mysticism and Logic)*; it is the wretched fruit of enlightenment thinking:

> Such, in outline, but even more purposeless, more void of meaning, is the world which Science presents for our belief. Amid such a world, if anywhere, our ideals henceforward must find a home. That man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs, are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling, can preserve an individual life beyond the grave; that all the labours of the ages, all the devotion, all the inspirations, all the noonday brightness of human genius, are destined to extinction in the vast death of the solar system, and that the whole temple of Man's achievement must inevitably be buried beneath the debris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain, that no philosophy which rejects them can hope to stand. Only within the scaffolding of these truths, only on the firm foundation of unyielding despair, can the soul's habitation henceforth be safely built. [21, p. 23]

CHAPTER THREE: EMPIRICAL SCIENCE AND THE EARTH AS THE CENTER OF THE COSMOS

The Logic of Absolute Motion

In the first chapter it was explained why scholastic philosophy considers absolute space a contradiction in reality, although not in the mind. Thus there is no such thing as absolute space. And since there is no such thing as absolute space, it logically follows that there is no such thing as local motion in absolute space and no such thing as a change in local motion in absolute space. That is, there is no uniform local motion and no accelerated local motion in absolute space. And since there is no such thing as absolute accelerated motion, there is no such thing as absolute force. All motion and all forces are relative to physical bodies, as Ernst Mach correctly argued [10, p.279].

Isaac Newton realized that the existence of absolute space cannot be demonstrated by uniform local motion, but he argued that the inertial effects associated with rotational motion demonstrated it. He gave his famous example of the concave surface of a rotating pail of water. Modern geophysicists follow Newton in considering phenomena such as the oblate shape of the earth, the rotation of the plane of vibration of the Foucault pendulum, and the diminishing of gravity at the equator as inertial effects associated with the absolute rotation of the earth.

Mach refuted Newton's argument by pointing out that, even in the case of rotational motions, we have knowledge only of relative places and motions. We observe only the relative rotational motion between a rotating body and the rest of the universe. We cannot logically conclude that the inertial effects associated with rotation would occur without the rest of the universe present, which would be the case if rotational motion were absolute. According to Mach, rotational effects can be explained with reference to relative frames. He argued: "The principles of mechanics can, indeed, be so conceived that even for relative rotations centrifugal forces arise" [10, p. 284]. A. Assis implemented this insight in his development of relational mechanics [8].

The Physics of Local Motion

The physical science that deals with motion in itself, without the consideration of masses and forces, is called kinematics. Kinematics is concerned solely with the locations, velocities and accelerations of physical objects that move locally in any way. These are entities that are subject to measurement, and there must be standards for their measurement.

Measurements of distances and angles, on a material object or in a void, ultimately depend on the use of rigid material rods on rigid material frames of reference. Even methods that use light to measure distance must be calibrated according to such a standard. Rigid rods and frames of reference have parts that remain fixed with respect to each other.

The surface of the earth provides a basis for rigid frames of reference for terrestrial measurements and for the calibration of astronomical measurements.

The fixed stars provide a rigid frame of reference for astronomical measurements. The fixed stars do not appear to us to move with respect to each other. This is because 1) they actually do not move with respect to each other; or 2) they move with respect to each other with a motion too slow to perceive; or 3) they are so far away that, even if they do move with significant speed with respect to each other, their motion is imperceptible to us.

The measurement of motion also requires a standard for the measurement of intervals of time. Since there is no such thing as absolute time (time is an accident, not a substance) all intervals of time are relative. Time is measured by comparing physical processes. Intervals of time are measured by comparison with some physical process presumed to be uniformly periodic. At one physical extreme we have an astronomical standard (the sidereal day). At the other extreme we have atomic clocks. In between we have pendulum and other mechanical clocks. If we compare the uniformity of two clocks and they agree (that is, m cycles on one always corresponds to n cycles on the other), then we can interchange them as standards. However, if they do not always agree, then we must assume that one is the standard and that the other drifts. If we can give a good physical explanation why the second clock drifts, then we are satisfied. But if not, then we reverse the process. However, it seems that God gave us astronomical time as the ultimate standard.

Astronomical Phenomena Pertaining to the Stability of the Earth

Believers in a mobile earth point to two well-known astronomical phenomena that they suppose convincingly demonstrate motion of the earth through absolute space. Those phenomena are stellar aberration and stellar parallax. Arguments for a moving earth based on them can easily be shown to be inconclusive.

The phenomenon of stellar aberration was discovered by James Bradley in 1726. It is the apparent displacement in the positions of stars attributed to the finite speed of light and to the transverse motion of the earthbound observer with respect to the ray of light from a star. The effect requires the slanting of a telescope at an angle away from the target star to allow light entering the objective lens to reach the eyepiece. The telescope must be tilted to allow the ray to travel down the axis of a transversely moving telescope. If the speed of light were infinite, that would not be necessary. Stellar aberration has long been used as evidence for motion of the earth through absolute space. Those who advance it as evidence for absolute motion of the earth assume two things. They first assume that light propagates like a wave through a medium called the ether. Second, they assume that the ether is at rest in absolute space. According to that view, motion of the star through the ether would not cause the effect; only motion of the earth through the ether would cause it. But, if the ether moved like a breeze through absolute space, the same effect would be produced. One could conceive of the earth at rest with the ether moving around it with the sun. Also, if the light is conceived as a beam of particles, which is the quantum mechanical view, then the effect is only one of the relative motion of the earth and star.

Albert Einstein, in his 1905 paper on special relativity entitled "On the Electrodynamics of Moving Bodies," treated stellar aberration as a phenomenon caused by relative motion of the earth and star [22, pp. 55-57]. Einstein calculated the first-order stellar aberration, which is caused by a "wobble" of the celestial sphere with respect to earth. The first-order effect is of equal magnitude for all the stars. Higher order aberration effects are caused by additional motions of stars with respect to the celestial sphere.

Stellar parallax is the angular displacement of certain stars against the background of the fixed stars. It was first observed by Friedrich Wilhelm Bessel in 1838. Astronomers attribute this to the optical effect called

parallax, which is the apparent displacement of two objects when viewed from two different positions. This occurs, for example, when one holds a pencil in front of his nose and views it with one eye and then other. The pencil appears to move relative to the background. In the case of stellar parallax, the two observations are made from the earth six months apart. The earth in then pictured as being at two different ends of its apparent orbit around the sun. It is assumed that earth moves with respect to the stars and that the sun remains fixed with respect to the stars. This means that there would be no parallax on the sun, something that has not been demonstrated. This explanation further assumes that the stars themselves are fixed in absolute space, something else that has not been demonstrated. The phenomenon of stellar parallax, therefore, does not conclusively demonstrate absolute motion of the earth.

E. Whittaker summarizes nineteenth-century optical astronomy and concludes that optical methods had been unable to detect the earth's alleged absolute motion through space:

> Fresnel inferred from his formula that if observations were made with a telescope filled with water, the aberration would be unaffected by the presence of the water—a result which was verified by Airy (*) in 1871. He showed, moreover, that the apparent positions of terrestrial objects, carried along with the observer, are not displaced by the earth's motion; that experiments in refraction and interference are not influenced by any motion which is common to the source, apparatus and observer; and that light travels between given points of a moving material system by the path of least time. These predictions have also been confirmed by observation: Respighi (*) in 1861, and Hoek (*) in 1868, experimenting with a telescope filled with water and a terrestrial source of light, found that no effect was produced on the phenomena of reflection and refraction by altering the orientation of the apparatus relative to the direction of the earth's motion. E. Mascart (*) in 1872 studied experimentally the question of the effect of motion of the source or recipient of light in all its bearings, and showed that the light of the sun and that derived from artificial sources are alike incapable of revealing by

diffraction-phenomena the translatory motion of the earth. [23, vol. I, pp. 113-114] [An asterisk indicates that a source is cited by the author.]

Optical Experiments Pertaining to the Stability of the Earth

The most famous attempt to measure the alleged motion of the earth through the ether by optical means was the Michelson-Morley experiment, first performed in 1887. The logic of the experiment is as follows: two coherent light beams are sent out from a beam splitter in mutually perpendicular directions, one in the direction of the earth's supposed motion and one perpendicular to it. After traveling equal distances on the apparatus, the two beams are reflected back to the beam splitter and into an interferometer. Calculations indicated that the roundtrip "upstream and downstream" and the roundtrip "cross stream" would take different periods of time, the upstream-downstream trip taking more time. So they should both arrive back at their origin out of phase and thus cause a shift in the interference fringes (from that expected for a null result). But no such fringe shifts were observed, which implied that earth does not move. But physicists like G. F. Fitzgerald and H. A. Lorentz, who were totally imbued with the notion of absolute space filled with ether, attempted to explain the null result of the experiment by making the incredible proposal that the apparatus "shrunk' in the direction of the motion just enough to conceal the earth's motion. According to J. S. Bell, Lorentz, rather than rejecting the notion of the motion of the earth through the ether, "preferred the view that that there is indeed a state of *real* rest, defined by the 'aether', even though the laws of physics conspire to prevent us from identifying it experimentally" [24, p. 77]. A. Assis explains the null result of the Michelson-Morley experiment in terms of relational mechanics. Assis maintains that the most straightforward explanation of that experiment is that there is no ether. He says: "Only the relative motion between the light, the mirrors, the charges in them and the earth are important, no matter what the velocity of these bodies relative to the ether or to absolute space" [8, p. 145].

Einstein expressed his belief in the fruitlessness of attempting to measure absolute motion of the earth. In the introductory paragraph of his 1905 paper on special relativity Einstein refers to "unsuccessful attempts to discover any motion of the earth relatively to the 'light medium,' which "suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest" [22, p. 37]. The attempts that he alludes to include stellar aberration, stellar parallax

and the Michelson-Morley experiment, all observations that predate publication of that paper.

Gerardus D. Bouw [25] describes a geostationary model of the universe that exhibits all observable astronomical kinematic phenomena, including the phases of Venus, stellar aberration and stellar parallax. It is a modified version of that of Tycho Brahe with the planets and the stars moving around the sun, which, in turn, moves around the earth.

*

Accelerated motion can be detected by actual physical effects, for example, compression or tension in an elastic material. However, the effects cannot tell us whether the acceleration is caused by motion with respect to absolute space or motion with respect to the rest of the universe.

In 1913 G. Sagnac, following a suggestion by A. Michelson, used light in an attempt to determine absolute rotational motion. The experiment was conducted as follows: Four mirrors were arranged in a square centered on the axis of a turntable so as to reflect a beam of light around the square. A light source, a beam splitter, and an interferometer were also placed at appropriate locations on the turntable. Two coherent beams of light were sent out from the beam splitter in opposite directions around the square back to the beam splitter and into the interferometer. When the turntable was at rest the beams arrived at the interferometer in phase with each other and produced a fringe pattern. When the turntable was rotated, however, shifts in the fringes were observed, which indicated that the optical lengths of the two paths were different. (The same observation was made later by different experimenters with the light source and observer standing off the rotating platform.) This was taken as a demonstration that the platform was rotating in absolute space [25, pp. 281–284; 26, pp. 55–58]. However, the same arguments apply for this experiment as were made above for mechanical effects of acceleration; that is, we do not know whether the Sagnac effect is caused by motion with respect to absolute space or motion with respect to the rest of the universe. It is not possible to test this directly because one cannot simply remove all the heavenly bodies. H. E. Ives seems to have recognized this, although he argued against the Sagnac effect as being an effect of the relative rotation of material bodies. In a 1938 paper that deals with the Sagnac effect he concludes:

> The observer on the apparatus has just one reference framework by which he can predict whether the Sagnac effect will appear or not; that framework is the pattern of radiant energy from the stars. If his apparatus rotates with respect to the stars he will observe a Sagnac effect, if it does not, then no matter how great a relative rotation it exhibits with respect to its material surroundings, there will be no Sagnac effect. [27, p. 44]

The results of optical experiments like the Sagnac experiment must be interpreted with great care because we do not have a clear understanding of the nature of light and its inertial effects. Light has been observed in various experiments to behave with apparently irreconcilable wave properties and particle properties. Waves are propagated; particles are projected or propelled. Any particular experiment must be interpreted according to whether a wave property or a particle property is being observed. If a wave property such as interference or diffraction is being observed, then light must be presumed to be a wave. Since a wave is propagated, it requires a medium. The medium that propagates light waves is called ether. Assumptions must be made about the ether, for example, whether it is at rest or moving and in respect to what. Particle properties of light manifest themselves in experiments that involve the exchange of energy and momentum between light and matter. Another consideration is the speed of light. Is it the same for all sources? How does reflection of light from a moving mirror affect its properties of wavelength, frequency and speed? Einstein, in his 1905 paper on special theory of relativity, assumed that the speed of light in a vacuum is always the same for everybody [22, p. 41]. However, others interpret empirical evidence to the contrary [8, pp. 139-140]. In his 1905 paper, Einstein interpreted light as a wave phenomenon and the constancy of the speed of light for all observers as a kinematical effect. That interpretation generates contradictions. However, in the next chapter a dynamic interpretation for the constancy of the speed of light will be given that is free from contradictions. That interpretation employs particle properties of light.

Comments on the Nature and Motion of Light

At this point it would be sensible to consider the general nature and the motion of light itself because its nature and its means of moving determine the interpretation of optical observations.

St. Thomas Aquinas following Aristotle held that light is an accidental form. St. Bonaventure held that it is a substantial form. It is interesting that neither held light to be a substance. Being a form, it exists in something else. As an accidental form, would the underlying "subject" be a material object or the void? And, as a substantial form, what is the underlying "matter"? St. Bonaventure believed in the plurality of substantial forms (more than one substantial form in a substance) and that the same matter underlies both material and spiritual substances. He believed that light is the common form of all things. The nineteenth-century view was that light is a disturbance of an ethereal medium that is propagated. Thus light was considered accidental in nature. The modern view is that light is substantial. Photons of light possess energy that can be transformed into matter.

There are three ways in which light might move: propagation, projection, and propulsion. In the so-called "wave theory," light is propagated as a wave, analogous to water and sound waves; this is the classical electromagnetic view. In the so-called "ballistic theory," light is viewed as a projectile that is given motion by its source and continues to move along by inertia; this is the picture we are given, rightly or wrongly, by quantum mechanics. A third view, which does not seem to have been given much attention by physicists, might be called the "self-propulsion theory." It is a combination of the modern and classical views. Light is seen as an independent entity like a photon. But it propels itself through the ether, analogous to a fish in water or a snake on land. There is a hint of this in the classical explanation for the propagation of an electromagnetic wave. In that view a varying electric field produces a varying magnetic field in its immediate vicinity, which in turn produces a varying electric field in its immediate vicinity, and so on. In this way light "wiggles," "crawls," "swims," "steps" or "walks" through the ether.

Geometrical and Physical Centricity of Earth

The earth is at the center of the universe because it is a place in the universe with special properties, just as geometric centers and centers of mass are places with special properties. The definition of “center” is not unique; for example, geometers have a number of different definitions for the “center” of a triangle. The earth is considered to be at the center of the universe because God created it first, built the rest of the universe around it, defined it as the standard of rest, and made it the home of man, who is a unique union of matter and spirit.

The centrality of earth in the universe might also be expressed geometrically and/or physically. And, as we shall see, there is evidence that it is; although it need not be so to be in accord with Scripture. Striking evidence that the earth is at or near the center of the universe comes from the observation of galaxies and quasars. (Quasars, from “quasi-stellar objects,” are star-like sources of light of unknown nature whose red shifts are large. They must be very bright to be visible at the great distances astronomers assign to them.) In the early 1970s, William Tifft at the Steward Observatory in Tucson, AZ analyzed red shift data from galaxies in all directions. His analysis showed that the red shifts are quantized. This can be interpreted to mean that the galaxies are arranged on concentric spherical shells. The quantization effect could be clearly observed only if the earth was close to the center of the shells. [See Russell Humphreys, “Our galaxy is the centre of the universe, ‘quantized’ redshifts show,” *TJ* 16(2):95–104 (2002).] Y. P. Varshni studied the red shifts of 384 quasars. Varshni concluded that if the quasar red shifts are real and distance related then “the Earth is indeed the center of the Universe. The arrangement of the quasars on certain spherical shells is only with respect to the Earth. These shells would disappear if viewed from another galaxy or a quasar. This means that the cosmological principle will have to go. Also, it implies that a coordinate system fixed to Earth will be a preferred frame of reference in the Universe. Consequently, both the Special and the General Theory of Relativity must be abandoned for cosmological purposes” [*Astrophys. Space Sci.* 43:3 (1976); 51:121 (1977)].

Other evidence offered as suggesting that the earth is at or near the center of the universe comes form the study of ambient microwave radiation. In 1965 A. A. Penzias and R. W. Wilson discovered that the earth

is immersed in a bath of microwave radiation corresponding to that found inside a box kept at a temperature of 2.7 Kelvin. This radiation, called *cosmic microwave radiation* (CMR), is very isotropic, having intensity variations with direction no greater than one part in one hundred thousand. Physicist V. F. Weisskopf made this observation concerning the isotropy of this radiation: “It is remarkable that we are now justified in talking about an absolute motion, and that we can measure it. The great dream of Michelson and Morley is realized. They wanted to measure the absolute motion of the earth by measuring the velocity of light in different directions. According to Einstein, however, this velocity is always the same. But the 3 K radiation represents a fixed system of coordinates. It makes sense to say that an observer is at rest in an absolute sense when the 3 K radiation appears to have the same frequencies in all directions. Nature has provided an absolute frame of reference. The deeper significance of this concept is not yet clear” [*Am. Sci.* 71, no. 5: 473]. However, observations show that the CMR wavelength spectrum is not isotropic in wavelength. Its wavelength spectrum is shifted down in one direction of the sky and shifted up by the same amount in the opposite direction. This phenomenon is called *dipole anisotropy.* It is attributed to the Doppler effect caused by a speed of about 260 kilometers per second of the earth relative to the radiation. Weisskopf’s enthusiasm is premature. There is not enough known about CMR to qualify it as an absolute frame of reference. Is it isotropic, stationary and thermally uniform throughout the whole universe? Or is it like our oceans, hotter in some places, cooler in others, with streams flowing through it? Dipole anisotropy suggests such streams when we take the earth as the center of rest. It seems then that CMR can no more provide a standard of absolute rest for the universe that can ocean water provide a standard of rest for the earth.

CHAPTER FOUR: THE LOGIC OF NEWTONIAN PHYSICS AND RELATIVITY

Newton’s Laws of Motion and Inertial Frames

The science of matter and motion, called mechanics, was greatly advanced by the work of Isaac Newton. In the *Principia* Newton encapsulated the dynamics of material bodies in three laws [17, pp. 25–26]:

> FIRST LAW: Every body continues in its state of rest or of uniform motion in a right line unless it is compelled to change that state by a force impressed upon it.
> SECOND LAW: The change of motion is proportional to the motive force impressed and is made in the direction of the right line in which that force is impressed.
> THIRD LAW: To every action there is always opposed an equal reaction; or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.

The first law is called the law of inertia. It states that a material body, by virtue of its inertial mass (“quantity of matter”) alone, will not change its state of rest or uniform linear motion without an outside influence being impressed upon it.

Newton defines the “quantity of the motion” (momentum) of a material body as the product of it mass and velocity. An applied force changes the momentum along the direction of the force. The second law states that if a force produces a change in the quantity of motion, then twice that force will produce twice the change, three times the force three times the change, and so on.

The third law is called the law of action and reaction. Whenever one material body “pushes” on another, the second pushes back with an equal force.

Newton did not give an adequate definition for the inertial mass of a body. He simply defined it as the product of the volume of a body and its density. Ernst Mach gave a much better definition by employing the third law. He stated: “All those bodies are bodies of equal mass, which, mutually acting on each other, produce in each other equal and opposite accelerations” [10, p. 266]. For example, consider two masses at the two ends of a constrained compressed spring on a level frictionless surface. When the constraint is removed, the expanding spring will cause both

masses to accelerate along the surface. If the accelerations are equal, the masses are equal. This definition would seem to work well on any rigid material frame of reference in which both masses start out at rest with respect to each other and with respect to the frame of reference and no external forces are present that produce a bias. Such a bias would be present, for example, if one performed the above procedure on an inclined surface rather than a level one. Then gravity would decrease the acceleration of the mass going uphill and increase the acceleration on the mass going downhill. In the case of unequal accelerations, the ratio of the masses is inversely proportional to the ratio of the magnitudes of the accelerations.

Newton said that his laws of motion apply in any frame of reference that is at rest in or moves in uniform linear motion in absolute space. These are called inertial frames. Today the term *inertial frame* is used simply to mean a frame in which Newton's laws of motion apply directly, without any reference to absolute space. Frames of reference in which Newton's laws do not apply directly (such as rotating rigid platforms) are called non-inertial frames. In such frames Newton's laws of motion have to be modified by the introduction of "fictitious forces," such as centrifugal and Coriolis forces. According to Newtonian mechanics, fictitious forces are forces that cannot be traced to physical interactions with other material bodies; they are the result of nonuniform and/or nonlinear motion of a frame of reference with respect to absolute space. According to Machian mechanics, the so-called fictitious forces are actually real forces that are associated with interactions arising from nonuniform and/or nonlinear motion of a frame with respect to the rest of the universe. A specific nature is given to those interactions by Andre Assis in his *Relational Mechanics* [8].

Ultimately, fictitious forces are explainable in terms of Newton's three laws because they derive from the inertial properties of matter contained therein. Therefore they are also called inertial forces. Newtonian mechanics does not give a reason for these inertial properties of matter; it only states them. Machian mechanics, on the other hand, attributes the inertial properties of a material body to the other matter in the universe. In the Machian view, every material body resists any change in the arrangement of the universe, and this is a collective phenomenon.

Newton's referencing his laws to absolute space introduces a certain ambiguity in his first law. In that law he refers to motion in a "right"

(straight) line. But what is a straight line? How can a straight line be defined in absolute space? If it is defined as the trajectory of a mass that has no force impressed on it, then his law suffers from circularity. And how would "trajectory" be defined in the first place? How does one determine geometrically whether or not a force is being impressed? In empty absolute space no coordinate grid can be established because there is no place to anchor such a grid and no standard for the measure of distance. Therefore the concepts of trajectory and straight line are meaningless.

Despite this Newton was immensely successful in using his laws to explain observed terrestrial and celestial motions. That is because his laws of motion do not require the notion of absolute space, as Ernst Mach pointed out. Newton's laws of motion only require rigid frames of reference in which they work. All the frames of reference in which his laws of motion have been empirically confirmed are frames fixed to material objects, which are relative frames not absolute ones.

Even though Newton's mechanics gave the science of physics a great boost, his faulty metaphysics pointed physics in the wrong direction. Newton's rejection of the scholastic view of space and time led the way to the plethora of esoteric and confused relativity-based cosmologies that we are plagued with today. His opposition to the scholastic view is clearly presented in the following passage from his paper *De gravitatione* (c. 1670), in which he defends the reality of absolute space:

> … we can clearly conceive extension existing without any subject, as when we may imagine spaces outside the world or places empty of body, and we believe {extension} to exist wherever we imagine there are no bodies, and we cannot believe that it would perish if God should annihilate a body, it follows that {extension} does not exist as an accident inherent in some subject. And hence it is not an accident. And much less may it be said to be nothing, since it is rather something, than an accident, and approaches more nearly to the nature of substance. There is no idea of nothing, nor has nothing any properties, but we have an exceptionally clear idea of extension, abstracting the dispositions and properties of a body so that there remains only the uniform and unlimited stretching out of space in length, breadth and depth. And, furthermore, many of

> its properties are associated with this idea; these I shall enumerate not only to show that it is something, but what is. [28, p. 618]

The scholastic argument, given in Chapter 1, is much sounder; it does not confuse abstraction with reality.

Furthermore, Newton's theology of creation was decidedly non-Catholic. He considered void not as a freely created entity but as a necessary effect of God, existing eternally along with Him, and, like God, perfectly simple and immutable. God had no alternative to creating matter in three-dimensional space. (That would seem to put an unreasonable limitation on God's power to create. He would not be free to create a higher-dimensional world, which does not seem to be an inherently contradictory notion.) Likewise, Newton considered absolute time to be uncreated. He viewed the eternity of God not as transcending time but as the enduring existence of God in absolute time. Newton perceived God as distinct from but effecting and living in infinite space and time. Moreover, he held that infinite space is the "sensorium" of God, in which He observes the world. Newton spelled out these views in *De gravitatione*, the *Principia* and elsewhere [see 17, pp. 41–67; 28, pp. 617–644].

Electrodynamics and Einstein's Postulates for Special Relativity

The notion of absolute space was to be looked at in a new light in the nineteenth century with the development of a completely new science, electrodynamics. This science dealt with the newly-identified electric and magnetic forces, which, although similar in some ways, were quite different from the familiar gravitational force. At the center of electrodynamics is a physical entity called electric charge, of which there are two kinds, positive and negative. If a material body possesses such a charge, it will exert a repulsive force on other bodies that possess the same kind of charge and an attractive force on bodies that possess the other kind of charge. All uncharged material bodes contain equal amounts of positive and negative electric charge, which cancel out the effects of each other making the body overall electrically neutral. Uncharged metals carry "free" negative charge, that is, charge that is free to move within the metal. But that charge is balanced by an equal amount of "fixed" positive charge, which makes the metal overall electrically neutral. Charged metals carry either a deficiency or an excess of negative charge, making them either positively or negatively charged. The free charge in a metal can move to constitute what is called an electric current. Because of their ability to conduct an electric current, metals are called conductors. Materials that do not possess "free" charge, and therefore cannot conduct an electric current, are called insulators.

There was yet another kind of material, called lodestone, which possessed a strange property. Pieces of lodestone were observed to attract or repel other pieces of lodestone, even with nothing in between them. And it was found that it could give this property to iron without losing it itself. This property came to be known as magnetism. Bodies that possess it are called magnets. Magnets were also observed to produce effects on electrically charged bodies, but those effects were different from the effects electric charges produced on each other. Magnets exerted forces on electrically charged bodies, but only on charged bodies that move relative to the magnet. If was observed that if a metal wire was moved toward or away from a magnet an electric current would be induced in the wire. If instead the magnet was moved in the same way relative to the wire an identical current would be induced. Thus the induced current was observed to depend only on the relative motion between the wire and the magnet.

A key figure in the development of the science of electrodynamics was Michael Faraday, who performed experiments with charged bodies, wires and magnets. In his attempt to understand what he observed he invented the concept of a field, which was mathematically developed by James Clerk Maxwell. The concept of a field eliminated the need to talk about action-at-a-distance. That is, one no longer had to think of charged bodies and magnets as exerting their effects instantly across empty space. Instead, they produce fields of force in the space around them, which in turn exert their effects by immediate contact. So there developed two approaches to electrodynamics, the action-at-a-distance approach, which was developed by Wilhelm Weber, and the field approach of Faraday and Maxwell. The latter won out in the minds of physicists, but not without the introduction of new perplexities that replaced those of action-at-a-distance.

The great achievement of the field approach to electrodynamics was the discovery that disturbances in an electromagnetic field are propagated as waves that travel at the same speed as light. Thus light came to be identified as an electromagnetic phenomenon. The perplexities introduced were associated with the notion of the luminiferous ether, the mysterious medium required for the propagation of electromagnetic disturbances. Is it identical to absolute space or distinct from it? If distinct, of what is it composed? Does it have a solid or fluid nature? Does it exist in absolute space; and, if so, is it at rest or does it move in the manner of an ocean current or perhaps multiple ocean currents? Does it travel with the source of the fields it propagates? Does it resist the motion of material bodies through it, thus giving rise to the phenomenon of inertia? Nineteenth century physicists tended to think of the ether, whatever they perceived its substantial nature to be, as being at rest in absolute space and as pervading all of space. H. A. Lorentz was the great champion of the ether notion. Albert Einstein was its great opponent.

The notion of ether also raises interesting questions for the scholastic philosopher. If the ether exists, is it a substance or an accident? If it is a substance, is it material or immaterial? If it is a substance, then arguments that deny the existence of absolute space, which is nothingness, would not apply to the ether, which is a created something. If the ether is a substance that pervades the whole universe, then the universe is a plenum and there is no void. If the ether is an accident, then in what subject does it exist? Is the ether a potency and, if so, to what? If it is a potency, what is its relation to

pure potency, that is, prime matter? Is the ether an incomplete substance, analogous to a disembodied human soul, and, if so, what completes it? Consideration of such questions could lead to a better understanding of electromagnetic phenomena.

Einstein presents the ethereal point of view at the beginning of his 1905 paper on special relativity [22, pp. 37–38]. He gives the Lorentzian explanation for the induced current in a conducting wire moving with respect to a magnet. According to the Lorentzian interpretation of Maxwell's field theory, the same current can be produced in the wire for two different reasons, depending on motion with respect to the ether. If the wire moves with respect to the ether, then the current is induced simply by the motion through the magnetic field. If the magnet moves, the current is induced by an electric field produced by the moving magnetic field. Thus in one case a magnetic field produces the current; in the other case an electric field produces the current. This is an asymmetry that is not inherent in the phenomenon itself because the exact same effect takes place no matter which object is moved. The asymmetry results from a misinterpretation of Maxwell's field equations. Maxwell's field equations state that a varying electric field at a point produces a magnetic field in the vicinity of the point and vice versa. However, the fields must be referred to their source (as Faraday and Maxwell did) and not to the ether (as Lorentz and Einstein did). And since the field of the magnet does not change with respect to the magnet when the magnet is moved there is no electric field produced by the moving magnet. So the current in the wire is induced by magnetic force in both cases. This is explained clearly and in detail by Andre Assis [8, pp.127–131 (also see 43, pp. 148-149 and 48, pp. 7-9)].

Einstein believed that elimination of the asymmetry required elimination of the notion of ether. If he had adopted the view of Faraday and Maxwell instead of the view of Lorentz, he would have been able to retain both the symmetry and the ether. Elimination of the ether was a drastic step that led to the theory of relativity of space and time with its confused notions and inherent contradictions.

Einstein built his theory of special relativity on two postulates. The first he called the "principle of relativity." It can be stated as follows: The fundamental laws of physics (mechanical and electrodynamic) have the same formulation on all rigid material frames of reference that move in uniform translatory motion with respect to each other. That would make

uniform translational motion through the ether undetectable by physical experiments. However, the postulate says nothing about accelerated motion. Accelerated motion could still be detected by inertial effects, as Newton had observed. So the notion of ether cannot be totally ruled out by this postulate.

The second postulate in that of the constancy of the speed of light in a vacuum. The first postulate already implies that the speed of light is constant with respect to the source. Otherwise, the fundamental laws of electrodynamics would differ from frame to frame and one could detect uniform motion in the ether. But for the speed of light to be constant with respect to the source each source would have to be accompanied by its own ether. Einstein went a step further because he wanted to eliminate the ether altogether. He said that the speed of a beam of light will have the same speed for all observers that move in uniform translatory motion with respect to each other, no matter in which frame it was emitted. Assis points out that this postulate makes light an oddity in the physical world. The speed of bullets shot from a gun with respect to a flatcar on which it rides does not depend on the speed of the flatcar, but their speed with respect to any observer depends on the speed of the observer relative to the flatcar. The speed of a wave is constant with respect to the medium in which it travels, as long as the medium is homogeneous. But its speed relative to an observer depends on the speed of the observer relative to the medium. However, in special relativity the speed of light does not depend on the speed of the observer relative to anything. According to Assis, that has never been empirically demonstrated. In fact, Assis cites evidence to the contrary [8, pp. 139–140]. In physical experiments light always shows similarities to projectiles or waves. But Einstein made light behave differently than either projectiles or waves. That is the source of the “paradoxes” and the counter-intuitional concepts of space and time generated by special relativity because in order to maintain the constancy speed of light for all observers one is forced to deny the possibility of common standards for measuring distance and duration.

Thus Einstein’s second postulate gives light a privileged place among physical phenomena. Making the speed of light constant for all observers makes it simulate infinite speed. According to classical physics only something traveling at an infinite speed would have the same speed with respect to all observers, independent of their states of motion. The speed of

light being the same for all observers gives rise to relativity's bizarre notions of space and time.

One such notion is called "relativity of simultaneity." Classically, simultaneity can be defined in terms of events that can be "connected" with signals that travel at infinite speed. This means that if a clock, at a certain instant, sends out an infinitely fast signal throughout the universe, events occurring at places throughout the universe when that signal is received are occurring simultaneously. But in Einstein's relativity, such simultaneous events are also connected by signals that travel at finite speeds. Consider a transmitter at rest with respect to a receiver located at another distant place. Assume next that, at a certain instant, the transmitter sends an infinitely fast signal to the receiver that contains information about events then occurring at its place. So the "observer" at the receiver can know what is happening at that instant at the place of the transmitter.

Next consider an "observer" moving at velocity **v** with respect to the rest frame of the transmitter and receiver. According to classical kinematics the signals exchanged between the transmitter and receiver would still be infinitely fast for such an observer. But according to relativistic kinematics that would not be so. The transmission and reception events would not be connected by a signal of infinite speed, but by a signal of finite speed, and therefore the transmission and reception of the signal would not be simultaneous events to such an observer. The formulas for the addition of velocities of special relativity transform the infinite speed of the signal sent by the transmitter to the receiver to a signal of finite speed for such an observer. The speed of the signal can take on a range of finite values, the value depending on the magnitude of **v** and its direction with respect to the line connecting the transmitter and receiver.

Consider a special case in which the observer travels in a straight line at speed v in the direction from the transmitter to the receiver. Then the infinitely fast signal appears to the observer to be traveling at the at the finite speed c^2/v, where c is the speed of light. Relativistic kinematics does not allow v to exceed c because that produces mathematically imaginary effects. Therefore the speed of the signal that the moving observer observes, although finite, is still equal to or greater than c. Furthermore, the fourth Lorentz equation, the time transformation, indicates that if the observer were to clock a signal speed greater than c^2/v he would see the temporal sequence of the events reversed; that is, the observer would see the receiver

receiving the signal before the transmitter transmits it. Since c^2/v is the transformation of the highest signal speed possible in the rest frame of the transmitter and receiver, it is the highest signal speed that can be clocked by the observer, so the reversal of cause and effect in his frame is not possible.

The above example should make it clear that although relativistic kinematics puts a limit on the relative speed of inertial frames, it does not put a limit on the speed of a signal sent within an inertial frame or even between inertial frames. However, relativistic dynamics puts a limit on the speeds of signals that are conveyed with objects that have inertial mass because a massive object cannot move faster than the speed of light in an inertial frame.

There are indications that some natural effects are transmitted with infinite or near-infinite speed. Physical observations provide strong evidence that certain gravitational, electromagnetic and quantum mechanical effects are communicated instantly or near instantly. But these effects cannot be used by intelligent agents to communicate information. This will be discussed at some length in the next chapter.

Kinematical Contradictions of Special Relativity

If something were to travel instantaneously it would appear so to all observers because that is a property of infinite speed. Postulating that a finite speed of light is the same to all observers is applying a property proper to an infinite thing to a finite thing. This is the source of contradictions in special relativity. It is analogous to postulating that the center of every finite circle is everywhere within the circle, a property that belongs only to infinite circles. A geometry based on such a postulate would produce contradictions.

Two results of special relativity are length contraction and time dilation. According to Einstein, observers moving with uniform linear motion with respect to each other will observe the other's measuring rod to be shorter and clock to be slower; both would observe the exact same effects in the other's instruments. This notion leads to contractions. The most famous contradiction is the "twin contradiction." It is usually called the twin "paradox." But it is not a paradox because a paradox is only an apparent contradiction. It is a genuine contradiction if presented in the proper way. It goes as follows:

Twins occupy two identical space rockets facing back to back. They both fire off at the same time and follow the same flight program. They rapidly accelerate away from each other to close the speed of light, move on uniformly for a time, slow down to a stop, reverse direction, accelerate to close the speed of light again, move on uniformly for some time, slow down and return together. According to special relativity, each pilot says that the other has aged more slowly and will be younger on the return. Because of the perfect symmetry of the arrangement, this can be nothing other than a genuine contradiction.

This "paradox" is usually presented in a non-symmetrical form. The one twin stays home on earth while the other goes off in a rocket and returns. Relativists resolve the paradox by saying that the twin who stayed at home remained at rest or in a state of uniform motion in space while the other was subjected to forces during acceleration and deceleration. So he's the one who really moved, and he will indeed be younger than his brother when he returns home. Here relativists resort to the concept of absolute space (or ether), which Einstein's theory was supposed to make "superfluous."

Here is a contradiction involving length contraction that might be called “the incredible shrinking bobsled contradiction”: A bobsled is made to slide in a long straight frictionless track. At midlength along the track a hole made equal to the length of the bobsled when the bobsled is at rest in the track. The bobsled is then taken to the end of the track, equipped with rockets, and accelerated down the track to close to the speed of light. An observer sitting at rest alongside the track will observe that the bobsled is shorter than the hole and that the bobsled will fall through the hole. The pilot of the bobsled will find the hole much shorter than the bobsled and the bobsled will pass right over the hole.

These and other inconsistencies in the special theory of relativity call for a rethinking of the problem of relative versus absolute motion.

Special Relativity without Contradictions

The most fundamental formulae of field electrodynamics are Maxwell's four field equations and Lorentz's force equation. Maxwell's equations describe the electric and magnetic fields of a source relative to the source. The Lorentz force equation describes the effects of an electromagnetic field on an electrically charged body moving relative to the source of the field. If the principle of relativity is a genuine feature of nature, what can we learn about nature by applying it directly to Maxwell's and Lorentz's equations? That and related questions were investigated by Nizar Hamdan in a series of five papers [30]. Hamdan conceives a dynamic relativity that is free of the contractions inherent in Einstein's kinematic relativity. He obtains the verified results of special relativity without employing its bizarre conceptions of space and time.

Hamdan distinguishes his principle of relativity from that of Einstein. For Einstein, a fundamental physical law is one that remains invariant (that is, retains the same mathematical form) under a Lorentz transformation, which is a set of transformation formulas that give Maxwell's equations the same mathematical form in all frames of reference moving in uniform linear motion with respect to each other. For Hamdan, any physical equation is a candidate to describe a fundamental law. The Lorentz transformation is a transformation of space and time coordinates that leads to the notions of length contraction and time dilation. Hamdan removes Einstein's constraint and thereby eliminates the need to refer to the Lorentz space-time transformation and its associated contradictions. For a given physical equation, the transformation rule is not imposed; rather it is sought.

Hamdan arrives at the constancy of the speed of light for all observers by applying his principle of relativity to both the Lorentz force law [30a] and to Maxwell's field equations [30e]. He shows that the constancy of the speed of light for all observers is a consequence of the relativity principle alone and need not be postulated additionally as Einstein did. But he argues that the constancy of the speed of light is not a kinematic effect, as it is in the special theory of relativity, but a dynamic effect. That is, it is not an effect of the properties of motion but an effect of the properties of light itself. The wavelength (which is inversely proportional to the momentum) and frequency (which is proportional to the energy) of a photon of light may vary from observer to observer, but their product (which is the speed of

light) remains constant. In Hamdan's analysis the notions of length contraction and time dilation and the contradictions associated with them have no physical significance. They have no significance because they are rooted in the notion that the constancy of light is a kinematic phenomenon, as Einstein proposed. If the constancy of the speed of light is a dynamic phenomenon, as Hamdan proposed, then length contraction and time dilation do not follow as necessary consequences.

In both Einstein's and Hamdan's dynamics a massive body cannot move in any inertial frame faster than the speed of light. But in both relativities massless signals can move faster than the speed of light within an inertial frame or between inertial frames. It seems that gravitational and electromagnetic interactions are such massless signals and thus are not constrained to speeds less than or equal to the speed of light.

In Hamdan's analysis the fundamental entities in the universe are energy and momentum. Space, time and mass are secondary. This is consistent with the scholastic notion that matter and motion are the two fundamental created entities. Place, time duration and quantity of matter are accidents of matter and motion. Hamdan shows that the invariance of the speed of light is rooted in the transformation properties of its energy and momentum for observers in relative motion. From his application of the relativity principle alone to the Lorentz force alone he arrives at the two great triumphs of Einstein's theory: the formula describing the increase of inertial mass with velocity and the formula identifying inertial mass and energy. Those formulas are also rooted in the transformation properties of energy and momentum and manifest a close relationship between inertial and electromagnetic phenomena.

Einstein altered classical mechanics to make it compatible with the Lorentz transformation. Newton's second law conformed if the velocity-dependent mass formula is used to define momentum rather than a velocity-independent mass. Hamdan obtains the same mechanical results as special relativity without the use of the Lorentz transformation [30c]. He first argues that his principle of relativity calls for a variable mass in Newton's second law. He argues that the variation of mass with velocity is a dynamical effect, not a kinematical one, as in special relativity. The work performed on a massive body by a force changing its location is absorbed as kinetic energy, which is expressed in the form of mass. The kinetic energy

does not reside in the motion but in the body; it is the material body itself that has the ability to do work, not its motion.

It must be admitted that in Einstein's analyses the connection of mechanics and electrodynamics seems more natural. The speed of light enters into the mechanical calculations by means of the Lorentz transformation, which connects with Maxwell's equations. However, in Hamdan's analyses the speed of light seems to be artificially introduced.

Proponents of Einstein's theory of special relativity claim that time dilation is experimentally confirmed. They point especially to two phenomena as confirming it: the transverse Doppler effect and the radioactive decay of mesons. The transverse Doppler effect is a shift in the wavelength of light that occurs to an observer viewing light from a source moving perpendicular to his line of sight. The transverse Doppler effect is predicted by the special relativity theory. There are explanations for the effect, however, that employ classical physics [see citations in 30d], but relativists have long claimed it as a unique feature of special relativity. The transverse Doppler effect is attributed in Einstein's relativity to time dilation. The transverse Doppler effect has been observed experimentally, and relativists claim that time dilation is thereby empirically confirmed. In his fourth paper [30d] Hamdan explains the effect using only the Lorentz force law and the principle of relativity, without the notion of time dilation. He thus shows that the transverse Doppler shift is not a kinematic effect, that is, it is not caused by motion; but it is a dynamic effect, an effect of the nature of light.

The transverse Doppler effect as a dynamic effect has a mechanical analog. The longitudinal tension in a cord held to a fixed center of rest might be caused by one of two things. First, it might be caused by a mass at the other end of the cord that is trying to increase its distance from the center of rest in the direction in which the cord is stretched. Second, it might be caused by a mass at the other end of the cord that is traveling in a circle around the center of rest, perpendicular to the direction in which the cord is stretched. If the mass was moving in a circle and the cord was very long and the speed of rotation was very slow, an observer at the center of rest might not be able to perceive the angular rotation of the cord and would, therefore, be unable to discern the cause of the tension.

Experiments have been performed in which radioactive mesons are accelerated to high velocities in particle accelerators. In those experiments

it has been observed that the half-lives of the accelerated mesons are greater than the half-lives of mesons at rest in the laboratory. Relativists claim that those experiments are confirmations of time dilation. They say that the experiments show that clocks "riding" on the accelerated mesons run slower than the clocks at rest in the laboratory. However, an analysis like Hamdan's analysis of the transverse Doppler effect might possibly explain that as an effect caused by the difference in internal energy between the speeding mesons and those at rest. The speeding mesons would have larger masses, and the larger masses might be associated with stronger binding forces, which mean greater half-lives.

E.A. Milne [31, pp. 34–48] argues that the Lorentz transformation formulas of special relativity express kinematical observational effects connected with the finite speed of light and do not reveal any deep secrets about the nature of space and time.

And now a few words about energy and momentum, the fundamental entities in Hamdan's perception of relativity: First, let us consider the intangible nature of energy. Recall that energy is the *ability* of something to do work on a material body. This "ability" is communicated, without loss, to the body on which it works. James Clerk Maxwell observed that energy is not capable of identification. He states:

> We cannot identify a particular portion of energy, or trace it through its transformations. It has no individual existence, such as that which we attribute to particular portions of matter.
>
> The transactions of the material universe appear to be conducted, as it were, on a system of credit (except perhaps that credit can be artificially increased, or inflated). Each transaction consists of the transfer of so much credit or energy from one body to another. The act of transfer or payment is called work. The energy does not retain any character by which it can be identified when it passes from one form to another. [9, p. 90]

The modern notion of energy echoes the scholastic notion of prime matter, which is matter out-of-which something exists. Prime matter is that which is in potency to substantial existence. It is pure potency because it has the potential to be any material thing, and it is the principle of permanence because it perseveres through any change. It exists separately

in the mind only. It does not exist separately in reality. It has no form in its rational character, yet it is never stripped away from form in reality. St. Thomas Aquinas in *On the Principles of Nature* points out that *prime matter* is “numerically one in all things.” That is, it “exists without dispositions making it numerically different.” Prime matter, like energy, is not capable of identification because it does not possess a character that can be identified when it passes from one form to another. And energy is like prime matter because it does not exist in itself but only in physical entities; it perseveres through physical transformations without a specific identity.

Another important property of energy is that it is strictly relative. The calculation of energy transfer takes into account only the communication of “parcels” of energy between one thing and another. It makes no use of an absolute source of energy. Maxwell points out that we cannot know the absolute energy of a body (if indeed such a notion makes sense):

> The energy of a material system can only be estimated in a relative manner.
>
> In the first place, though the energy of the motion of the parts relative to the centre of mass of the system may be accurately defined, the whole energy consists of this together with the energy of a mass equal to that of the whole system moving with the velocity of the centre of mass. Now this latter velocity—that of the centre of mass—can be estimated only with reference to some body external to the system, and the value which we assign to this velocity will be different according to the body which we select as our origin.
>
> Hence the estimated kinetic energy of a material system contains a part, the value of which cannot be determined except by the arbitrary selection of an origin. The only origin which would not be arbitrary is the centre of mass of the material universe, but this is a point the position and motion of which are quite unknown to us. [9, pp. 90-91]

One could go further and say that the notion of absolute energy is meaningless because the notion of motion of the center of mass of the universe means its motion through absolute space, which is meaningless.

Maxwell gives us another reason for considering the notion of absolute energy meaningless, although he does not reject the idea:

> But the energy of a material system is indeterminate for another reason. We cannot reduce the system to a state in which it has no energy, and any energy which is never removed from the system must remain unperceived by us, for it is only as it enters or leaves the system that we can take any account of it.
>
> We must, therefore, regard the energy of a material system as a quantity of which we may ascertain the increase or diminution as the system passes from one definite condition to another. The absolute value of the energy in the standard condition is unknown to us, and it would be of no value to us if we did know it, as all phenomena depend on the variations of the energy and not on its absolute value. [9, p. 91]

The relative nature of energy is manifested in the observation that its transfer is a local phenomenon; that is, the giver and the receiver of a “parcel” of energy are in the same place at time of the transaction.

Adding the accidents of place and time duration to the notion of energy leads to the complementary fundamental notion of momentum. If energy corresponds to matter in place, momentum corresponds to matter in motion. Momentum has the same relation to time as energy has to position, namely, the rate of change of the momentum of a body with respect to time is the same as the rate of change of its energy with respect to position. And like energy, it is a relative quantity that is conserved in energy transactions.

Again, recall that the energy possessed by a body actually resides in the body itself and not in its position or speed, although it depends on them in an accidental way. The same is true for momentum.

General Relativity and Absolute Space

In his theory of general relativity, Albert Einstein proceeded to formulate the laws of physics so that they look the same in all coordinate systems moving relative to each other, whether uniformly or nonuniformly, linearly or nonlinearly. To do this the notions of absolute motion in space and absolute rest in space had to be eliminated. This was made possible by the equivalence of inertial and gravitational mass, which allowed for gravity to eliminate absolute motion. Motion of massive bodies could then be looked at as being determined by the geometry of space-time that was shaped by gravitating masses. The first law to be formulated for all possible coordinate systems had to be that of gravity itself because of its central importance. Einstein put a lot of effort into this problem. His work resulted in the formulation of his famous gravitational field equations, a set of ten differential equations for the metric of space-time. These are the equations modern cosmologists use to model the universe.

Einstein was strongly influenced by the thinking of Ernst Mach. He wanted to incorporate Mach's ideas into his theory of general relativity but was not able to do so satisfactorily [see 2, pp. 192-199; 8, pp. 125-159; 11, pp. 242-244; 28. p. 6; 32, pp. 284-288]. For Mach, the concept of space as an independent entity has no place in physics, and Einstein did not succeed in removing it. In his theory of general relativity, Einstein did not eliminate space and time as independent entities even though he combined them into *space-time*. But he still treated space and time as realities that are independent of the matter that determines them. So one could contemplate removing all the matter from the universe and yet have space and time remain. That is metaphysical thinking, not physical thinking. But his space-time differed from absolute space in that it was something that both acted and was acted upon. Masses in their passive inertial role are "guided" by space-time and in their active gravitational role "shape" space-time. General relativity did not eliminate space, but it did deprive space of its Newtonian absoluteness by giving it a passive quality.

The reason that Einstein failed to eliminate an independent space-time seems to be that he actually started out with one. In general relativity Einstein starts out with a four-dimensional space-time manifold that is anchored to nothing. A manifold is a topological space (a continuous set of points with certain properties) with a Euclidean structure. That means that it

is a space on which a constant Pythagorean metric is imposed (the metric gives a non-negative number for the distance, or separation, between two points). That Euclidean structure is then deformed by matter/energy imbedded in the space. This deformation is manifested by a varying metric described by his ten gravitational field equations. Einstein's space-time is not generated by matter/energy but is co-existent with it and given shape by it.

At this point let us recall what was said about Newtonian absolute space. It was mentioned earlier that in empty Newtonian absolute space no coordinate grid can be established because there is no place to anchor such a grid and no standard for the measure of distance. Therefore the concepts of trajectory and straight line are meaningless. Newtonian absolute space might be called a reverse abstraction. The notion of extension is abstracted from material bodies, in which it has real intrinsic meaning, and applied to empty space, in which it has no real intrinsic meaning. Extension is an accident of matter, whose ultimate standard of measurement is a material measuring rod. The notion of extension in empty space without matter is meaningless because it an accident without a subject in which to inhere. Furthermore, the notion of three-dimensional emptiness is theologically objectionable when it is paired with the notion that before creation empty three-dimensional space existed alongside God as a parallel infinity. As previously noted, sound theology informs us that before creation there was no infinite three-dimensional void into which God injected matter. Before creation there was nothing but God.

The *Catholic Encyclopedia* (1914) nicely expresses the position of the scholastic masters on absolute space:

> The traditional philosophy of the Catholic schools rejects absolute space. Newton's idea is incompatible with the concept which the great doctors of the school, following Aristotle, formed of quantity. Suarez declares that space is only "a conceptual entity [*ens rationis*], not, however, formed at will like chimeras, but extracted from bodies, which by their extension are capable of constituting real spaces" (Met. disp., 51). The expression *ens rationis* may be equivocal, but it expresses somewhat exaggeratedly the very active part played by the human intellect in the construction of space. Space is not

> material bodies themselves, since it appears to be rather a receptacle containing them. From this point of view it must be pure extension, an unqualified quantity. In the strict sense of the terms a quantity without quality is contradictory; for quantity is only the multiplicity of the homogeneous parts in the unity of a body; it is the distribution of an essence, simple in its formal determination. Multiplicity implies a thing that is multiplied, and distribution something that is distributed. Every quantity is the quantity of something; all extension is therefore, in itself, the extension of an extended substance. Yet quantity is something more than a modal accident; it is in truth the absolute accident *par excellence*; it confers on a substance a perfection such that, granted the existence of a substance, the corporeal body is measured by its quantity. It is none the less true that quantity postulates a quantitative substance; and, in a sense, entirely different however from the fancies of ancient physics, it may always be said that an empty quantity is a contradiction in terms. From this we must conclude that extension is only a derivative of quantity; a non-qualified extension, pure extension, pure space in the reality of the corporeal world is contradictory. We conceive it, however, and what is, properly speaking, contradictory is inconceivable. The contradiction arises when we add the condition of existence to pure space. Space is not contradictory in the mind, though it would be contradictory in the real world, because space is an abstraction. Extension is always the extension of something; but it is not the thing extended. Mentally we can separate extension from the substances from which we distinguish it; and it is extension thus separated, conceived apart, which constitutes the space of the universe. Space is therefore as real, as objective, as the corporeal world itself, but in itself it exists apart only in the human mind, seeing that in the reality of existing things it is only the extension of bodies themselves. [16, article entitled "Space"]

The above critique of Newton's absolute space can be also applied to the inertial spaces of special relativity because conceptually they are either

simply subdivisions of absolute space that move in absolute space or, more confusing yet, an infinite set of independent absolute spaces that move at all speeds relative to one another.

Einstein's four-dimensional space-time is also subject to the same critique. It is in no way clear how Einstein makes the transition from topological space to physical space. In his paper "The Foundation of the General Theory of Relativity" (1916) Einstein states that his "introduction of a system of reference serves no other purpose than to facilitate the description of the totality of such coincidences." The "coincidences" are "the meeting of the material points of our measuring instruments with other material points" [22, p. 117]. But he treats the reference (coordinate) system that "facilitates" the description of such coincidence as a free agent, not as something that depends on those coincidences for its existence. Thus it differs little in its conceptual fundamentals from Newton's absolute space. Further, in general relativity, matter/energy imposes a metric, which is accidental, on the four-dimensional manifold (system of reference), which is a mathematical (mental) object that has no substantial existence.

General relativity failed to give a cosmic origin to the inertia of a body. [see 8, pp. 148-159] According to Mach's principle, a body in otherwise empty space should possess no inertia. But Einstein was not able to achieve that result. According to general relativity such a body *would* possess inertia. Also, general relativity predicts that the surface of a rotating pail of water would retain its concave shape if the rest of the matter in the universe disappeared. That too violates Mach's principle. Further, although general relativity employs the proportionality of gravitational and inertial mass, it is unable to give a reason for it.

St. Thomas Aquinas said that space is a *privation* and not a *negation*, that is, it is the absence of matter from where it ought to be and not its absolute absence. He said that before the creation of the world there was no space because there were no "real dimensions" and no "place" [4, p.97; 5, Part I, Q. 46, A. 1, Reply Obj. 4]. One can apply St. Thomas' reasoning to the consequences of general relativity. The fact that in general relativity a body has inertia in the absence of other masses implies that there is a coordinate system in which acceleration is measured. But it is impossible to construct such a coordinate system because there are no physical objects on which to fix it (no "real dimensions") and no measuring rod to measure it. The isolated body itself could not be a measuring rod because to make

measurements it would have to be moved from one place to another. But in such a situation there is no such thing as “place,” and thus moving it from place to place is meaningless. Also, the object itself could not be the origin of a coordinate system in which its acceleration is measured because the body always remains at the origin.

It seems that freestanding (independent of matter) coordinate systems have introduced immense complications and confusion into physics that far outweigh any simplifications they may have produced. J. B. Barbour noted:

> Einstein himself commented [citation given] that the simplest way of realizing the aim of the theory of relativity would be to formulate the laws of motion directly and *ab initio* in terms of relative distances and velocities—nothing else should appear in the theory. He gave us the reason for *not* choosing this route its impracticability. In his view the history of science had demonstrated the practical impossibility of dispensing with coordinate systems. He therefore adopted an indirect approach and was guided, it seems, more by gut intuition than a clear formulation of principles that would of necessity lead to the realization of his aims. [28, p. 6]

This leads us into the subject of the next chapter, namely, relational mechanics, in which the laws of motion *are* formulated directly in terms of relative distances, velocities and accelerations.

CHAPTER FIVE: THE LOGIC OF RELATIONAL PHYSICS

Relational Mechanics

The *Catholic Encyclopedia* (1914) reduces the views of philosophers concerning space to two fundamental notions:

> To recall all the successive explanations of the nature of real space given by the great philosophers it would be necessary to go through the history of philosophy; but, leaving aside the complete negation of extension, all the doctrines, from Hesiod (cf. Aristotle, IV Phys., vi, 213b) to our day, fluctuate between the idea of absolute space, a real substance independent of the bodies it contains, and purely relative space, a mental fiction based on the real extension of material bodies. The most radical expressions of these two conflicting views are those of Newton and Clarke, on the one hand, who consider space as the *sensorium* of God, and on the other, of Leibniz, who asserts that there is no space independent of extended bodies, and reduces it to “the order of co-existing things.” [16, article entitled “Space”]

In his much cited foreword to Max Jammer’s *Concepts of Space: The History of Theories of Space in Physics* [2], Albert Einstein clearly and succinctly presented those two conflicting notions of space as “container of all material objects” and as “positional quality of the world of material objects.” Philosophers and historians of science use the word “absolute” space when referring to the first notion and “relational” space when referring to the second. The two notions of space give rise to two different ways of doing physics. This first way employs the notion of absolute space and its derivatives, such as inertial spaces, and the consequent notion of freestanding coordinate systems, which is the cause of much confused thinking in physical matters. The second employs only direct physical quantities and their relations, without the intermediary of freestanding coordinate systems.

Albert Einstein recognized the limitations of using the elusive notion of freestanding coordinate systems in physical systems but argued that it was unavoidable:

> We want to distinguish more clearly between quantities that belong to a physical system as such (are independent of the choice of coordinate system) and quantities that depend on the coordinate system. One's initial reaction would be to require that physics should introduce in its laws only the quantities of the first kind. However, it has been found that this approach cannot be realized in practice, as the development of classical mechanics has already clearly shown. One could, for example, think—and this was actually done—of introducing the laws of mechanics only by the distances of material points from each other instead of coordinates; a priori one could expect that in this manner the aim of the theory of relativity should be most readily achieved. However, the scientific development has not confirmed this conjecture. It cannot dispense with coordinate systems and must therefore make use in the coordinates of quantities that cannot be regarded as the results of definable measurements. [8, p. 147]

It seems strange that Einstein should so readily dismiss the employment of relational quantities, considering the conceptual simplification they offer, for simplification is what he sought. Instead he pursued the complex way to simplification. He describes the agony of his pursuit for the equations of general relativity as follows: "In the light of knowledge attained, the happy achievement seems almost a matter of course, and any intelligent student can grasp it without too much trouble. But the years of anxious searching in the dark, with their intense longing, their alternations of confidence and exhaustion and the final emergence into light—only those who have experienced it can understand that" [33, pp. 282-283].

Andre Assis seems to have accomplished what Einstein said couldn't be done. He eliminated the need for freestanding coordinate systems in physics. Assis proposed a new mechanics that implements Mach's principle quantitatively [8]. It is a shift of paradigm away from Einstein's theories of relativity, of which he is quite critical. Assis applies Weber's law for the interaction of electric charges to the interaction of masses and posits the *principle of dynamic equilibrium.* The latter states that the sum of all forces of any nature acting on any body is always zero in all frames of reference.

Assis calls this new mechanics *relational mechanics* because it employs only relative quantities, that is, it employs only the distances between material bodies and the relative velocities and accelerations between material bodies. He uses the word *relational* to distinguish this mechanics from Einstein's relativistic mechanics; but relational mechanics, unlike relativistic mechanics, is completely relativistic because all forces are referred to relative distances, velocities and accelerations of bodies and not to absolute space or inertial frames. According to relational mechanics, Ptolemaic astronomy is equivalent both kinematically and dynamically to Copernican astronomy. The choice of one or the other is one of pure convenience since there is no such thing as absolute motion, either in the kinematic sense or in the dynamic sense.

Relational mechanics posits a principle similar to Newton's third law of motion, but it replaces Newton's second law with the statement that the total force on any material body is zero in every frame of reference. For example, the static gravitational force acting on a freely falling body by the earth is cancelled by the dynamic gravitational force acting on it by the rest of the bodies in the universe. Since both forces are proportional to the gravitational mass, all bodies will fall to earth at the same rate. Another example: The force of attraction of the sun on the earth is balanced by the centrifugal force exerted on the earth by the rest of the bodies in the universe. Because they depend only on relative distances and motions, these forces are numerically the same in any frame of reference even though their mathematical expressions may be different. This contrasts with Einstein's relativity, where the mathematical expressions are required to be identical in different frames of reference, but numerical values for the quantities they represent may differ.

Assis applies the mathematical expression that W. E. Weber (1804–1891) used to express the electrodynamic force between two electric charges to the gravitational interaction between two masses. The expression has three terms, each of which is proportional to the product of the two gravitational "charges" (masses). The first term is inversely proportional to the square of the distance between the two masses. This is Newton's static gravitational attraction. The second term is also inversely proportional to the square of the distances between the two masses and proportional to the square of their relative speed along the line connecting them. The third term is inversely proportional to the distance between the two masses and

directly proportional to the relative acceleration along the line connecting them. The first term always represents an attractive interaction. The second term always represents a repulsive interaction. The third term represents a repulsive interaction if the relative acceleration of the masses is toward each other. All interactions are along the line connecting the two masses. Assis includes a factor that decreases the force exponentially with distance between the masses to avoid a paradox created by the concept of a universe infinite in extent. However, that factor is not really needed. The only reason for postulating a universe infinite in extent is to avoid the problem of a universe collapsing in on itself because of gravity. And that is only a problem if one considers the universe as having always existed. If one accepts the fact that the universe was created only several thousand years ago, then one need not postulate a universe infinite in extent.

Assis applies his gravitational theory to a model of the universe that is homogeneous on a large scale, static, and in dynamic equilibrium, using the currently accepted values for the average mass density of the universe, the radius of the universe, and the gravitation constant. He looks at the interaction of a mass nestled deeply within that universe with the rest of the universe. He then shows that Newton's second law of motion holds with respect to "the frame in which the distant matter [in the universe] is at rest, despite the peculiar velocities in this frame" [8, p. 178]. In his recovery of Newton's second law of motion the gravitational mass appears where the inertial mass appears in Newton's law. Thus he demonstrates the equivalence of gravitational and inertial mass. He also recovers Newton's first law of motion, again with the gravitational mass in the role of inertial mass and the above-mentioned frame of reference replacing absolute space. Relational mechanics also predicts quantitatively that the inertia of a body would vanish if the rest of the matter in the universe were to disappear. It further predicts that the curvature of the surface of a pail of rotating water is proportional to the amount of mass in the universe. The theory also yields an expression for the precession of the perihelion of planetary orbits that agrees to the first order with that given by general relativity. General relativity's ability to provide a calculated value equal to the observed value for the precession of the perihelion of Mercury helped vault that theory into prominence.

As mentioned earlier, Assis also explains the null result of the Michelson-Morley experiment in terms of relational mechanics. The

Michelson-Morley experiment failed to detect the supposed motion of the earth through the luminiferous ether. Assis says that the most straightforward explanation of that experiment is that there is no ether. He says: “Only the relative motion between the light, the mirrors, the charges in them and the earth are important, no matter what the velocity of these bodies relative to the ether or to absolute space. In this regard the results obtained by Michelson and Morley agree completely with Weber’s electrodynamics, as in this theory, the ether plays no role” [8, p. 145].

Assis further proposes that observed phenomena attributed to relativistic time dilation are better interpreted by relational mechanics. For example, the half-lives of mesons are observed to increase with their speed. It is usually explained that it is because the clocks “riding” on the moving mesons run slower than clocks at rest. Assis thinks that a simpler explanation is that “the half-lives of the mesons depend on their high velocity relative to the distant material universe” [8, p. 133]. This way of explaining such phenomena, he says, is more in agreement with the standard procedures of physics and suggests new avenues of experimental research.

Applying Mach’s principle but reasoning along different lines, Amitabha Ghosh arrived at a similar mathematical expression to that of Assis for the interaction of two gravitational masses, one of which he treats as a test body [34]. He focuses in on the second term, the term that contains the square of the relative velocity along the line joining the masses. He adjusts this term so that it represents an interaction that always acts in the opposite direction of the velocity in the manner of a cosmic viscous force. Ghosh calls this interaction *cosmic drag*. Cosmic drag is not easily detectable by experiment because it is a very small effect. But, since it acts on photons of light decreasing their energy, it gives rise to the observed galactic red shift. Thus Ghosh gives an explanation for the red shift and Hubble’s law without the big bang and expansion of the universe. The notion of light losing energy as it transverses the cosmos is called *tired light*. Other mechanisms for tired light have been proposed in addition to cosmic drag, but Ghosh claims that cosmic drag is the only testable mechanism.

Relational mechanics cosmology easily accommodates cosmic microwave radiation. Assis and Ghosh shatter the myth that the big bang advocate George Gamow and his associates were the first to predict the

existence of the cosmic microwave radiation (CMR) prior to its discovery by Penzias and Wilson in 1965 and that CMR supports the big bang hypothesis exclusively. They cite a number of researchers that predicted CMR in a stationary, nonexpanding universe. Such predictions not only predate those of Gamow et al. but also more accurately predicted the temperature of the radiation. The earliest prediction discovered in their literature searches was made in 1896 by C. E. Guillaume, who estimated a temperature between 5 and 6 degrees Kelvin.

The major objection physicists have to a mechanics that implements Mach's principle is that it requires instantaneous-action-at-a-distance. With the ascendancy of the theory of special relativity, it has become scientific dogma that the effect of any physical disturbance cannot be communicated faster than the speed of light, and Mach's principle demands that any material body and the rest of the universe must instantly sense any change in their relative distances and motions. However, it was argued in the last chapter that special relativity does not necessarily rule out physical causes propagating faster than the speed of light. More will be said about instantaneous-action-at-a-distance in a later article.

Mach's principle is anathema to quantum theorists, who give great importance to fields. They point out that the fields of elementary particles, either real or virtual, occupy all of space-time. These fields, which they say cannot be eliminated, possess Lorentz invariance and can be considered a modern ether [see 11, p. 244]. In response, it can be said that those fields are not physical entities. They are pure mathematical entities because they are expressed in terms of complex numbers and points in Einstein's space-time fabric, which is a mathematical entity, not a physical one. They are indispensable only insofar as one accepts the absolute space-time of relativity as a working paradigm [see 2, pp. 212-213]. Also, the field concept does not explain the quantum phenomenon of *entanglement*, in which physical effects are communicated instantly without the medium of fields.

Although Assis says that the model for the universe he prefers is an infinitely large, unbounded, eternal universe, the model he worked with was a finite, bounded universe. It does not matter in relational mechanics how old the universe is. The main requirement is that it is in dynamic equilibrium. So it seems that relational mechanics cosmology can be made to harmonize with Genesis. Furthermore, it makes it easy to place earth in

its rightful position as the center of rest in the universe. Because of its strong foundation in fundamental physics, relational mechanics cosmology has the potential to supplant cosmologies based on Einstein's general relativity.

Absolute and Relational Spaces United

The lack of resolution of the centuries-old debate between the proponents of absolute space and the proponents of relational space led J. Earman to make the following conjecture: “My own tentative conclusion from this unsatisfactory situation is that when the smoke of the battle finally clears, what will emerge is a conception of space-time that fits neither traditional relationism nor traditional substantivalism. At present we can see only dimly if at all the outlines the third alternative might take” [as quoted in 2, p. 236]. Jammer explains “substantivalism” as denoting that “space has the ontological status of an independent reality ‘as a kind of substance’” [2, p. 216]. Jammer further cites W. E. Johnson, “[A] theory of space conceives space as ‘substantival’ if it ascribes spatial positions directly to the individual points of space themselves and only in a derivative sense to material particles in virtue of their occupation of points in space,” and “space is ‘adjectival’ if the spatial characteristics of a material particle belong to it in a primary and underived sense” [2, p. 217]. Earman’s third alternative, if not a completely new notion of space, would be a union of relative space with absolute space. Often the resolution of a conflict resides in the recognition that both sides are partially correct and reconciles them.

Relational space and absolute space are alike in that they both require the notion of extension in three dimensions. And both depend on physical entities as standards for the measurement of extension. The difference is that in absolute space the extension and its derivatives (velocity and acceleration) are referred to a freestanding absolute mathematical frame of reference in a void while in relational space they are referred to other material bodies. Absolute space is spoken of in the singular, that is, there is only one frame of rest. Relationalism, on the other hand, actually requires that one speak of space in the plural because each ponderable body is accompanied by its own space. So there are many possible frames of rest; the definition of rest is arbitrary.

It seems possible to make absolute space into relational space by considering absolute space not as a void but as a special kind of plenum that each ponderable body sees as its own [see 35 pp. 230-231]. The plenum here proposed by the author of this essay is a continuous uniform mixture of positive and negative charge with equal charge densities and no mass density. Thus the plenum has overall charge neutrality. Disturbances in the

medium are propagated by local dipole-like fluctuations in the densities of charges. Unlike the charge on massive particles, the plenum charges are substances, not accidents.

The inspiration for this comes from both the electrodynamics of Maxwell and Hertz and the electrodynamics of Weber and Kirchhoff. Maxwell introduced the notion of free space displacement current, analogous to the polarization currents produced in a material dielectric by time-varying electric fields [see 36, pp. 84-101]. This is what paved the way to the electromagnetic wave equation and its consequent, electromagnetic radiation propagating through absolute space at the speed of light. However, since physicists gave reality to electric and magnetic fields in a void, they did not view these free-space displacement currents as real currents. Rather, they saw them in terms of time-varying electric fields producing magnetic fields.

Weber and Kirchhoff, employing instantaneous-action-at-a-distance electrodynamics, showed that electromagnetic disturbances travel along wires at the speed of light. However, their electrodynamics requires a medium containing electric charge to propagate electromagnetic disturbances. Thus the notion of the propagation of electromagnetic energy in an absolute void and the apparent empirical confirmation of this notion might seem to discredit the notion of relational space, which the electrodynamics of Weber and Kirchhoff employed.

Maxwell and Lorentz proposed the ether to be an incompressible fluid. The model proposed here employs a twofold electrically charged compressible ether and will be referred to as the "twofold electrical ether model" (TEEM). The continuous nature of the two charges insures that motion through them is a meaningless concept because there is no operation by which such motion in it can be detected. The charge mixture has a certain "viscosity" that resists fluctuations in charge density. The non-zero viscosity of the ether is a consequence of non-zero values for the permittivity and permeability of "free space" (ε_0, μ_0). Since the charges are not material, there are no mechanical interactions with the material bodies immersed in them.

Changes in distance-dependent electric forces along the line connecting two charged bodies immersed in the medium are communicated instantly. The medium is transparent to such instantaneous-action-at-a-distance forces. However, changes in the electric forces caused by changes in the

dispositions of the charges causing the forces would be propagated perpendicular to the direction of change by dipole (and possibly higher order) polarization currents induced in the twofold-charged medium, just as in a material dielectric. Thus the propagated disturbance is transverse.

The density fluctuations manifest themselves as the propagation of an electromagnetic field. They can be located on a coordinate grid fixed to any ponderable body immersed in the medium. The speed of propagation of a fluctuation can then be measured with respect to such a grid. Since the medium itself is unobservable anywhere and motion through the medium meaningless, every ponderable body can be assumed to be at rest in the medium. Therefore the speed of the propagation of the fluctuations is the same in the coordinate grids of all ponderable bodies immersed in the medium, whether they be the source or the sink of a fluctuation. In other words, the speed of light is the same everywhere in the plenum. Thus the constancy of the speed of light is not an effect of the properties of space-time as it is in the theory of special relativity. Rather it is a property of the uniform locally indistinguishable nature of the medium of propagation.

The speed of light being constant everywhere means that for a sinusoidal disturbance the product of the frequency and wavelength is constant. But for a given disturbance the wavelength and frequency can vary from grid to grid but their product must remain constant. Therefore they must vary inversely to each other. Consider now the relationship between the source of a sinusoidal emission and a sink moving with respect to the source. The problem is to determine the wavelength and frequency measured at the sink compared to those measurements at the source. Since both are at rest with respect to the medium, classical Doppler analysis does not apply. The problem seems to be one of dynamics rather than kinematics. The solution, it seems, would call for consideration of how the fluctuations transfer momentum and energy from the source to the sink.

The following assumption can be made on the basis of empirical evidence: Electrical (coulomb) force interactions along the line connecting two charged bodies are instantaneous, Action and reaction must be instantaneous if Newton’s third law and its consequence, conservation of momentum, is to hold globally. Otherwise, the medium, which is equivalent to a void, would have to transfer momentum by longitudinal waves, which is not possible according to Maxwell’s equations. (G. Green pointed out that a longitudinal wave would not be propagated if the speed of interaction is

indefinitely great or indefinitely small [see 23, Vol. I, p. 145]. An indefinitely great velocity is supported by an incompressible medium and an indefinitely small velocity is supported by a perfectly compressible medium.) This instantaneous action also applies to other physical cause-effect relationships (for example, gravitational interactions, entanglement). This will be treated in more detail in a later article.

It can also be safely assumed that information about physical events can be communicated to intelligent observers only at speeds equal to or less than the speed of light. For example, the instantly changing forces in coulomb interactions cannot be communicated instantly to an intelligent observer because the intelligent observer cannot observe the change in force directly; he must observe the effect of the changing force, which does not occur instantly because of unavoidable inertial and elastic effects in his instrument of observation. Also, it seems that the instrumental effects are sensitive to the distance from the source of the change to the observer, this being a holistic effect of the universe [see 37, pp. 204-219].

The above postulate also contains within it the implication that a massive body can travel with respect to a coordinate grid fixed to a ponderable body no faster than the speed of light.

In the TEEM the "ether" is at rest with respect to all ponderable bodies, The TEEM is similar in some respects to the dragged ether model. It differs from the dragged ether model in that that it is purely relational; motion through absolute space is a meaningless concept. In the dragged ether model, on the other hand, a ponderable body "drags" the ether with it through absolute space. W. Panofsky and N. Phillips [38, p. 282] list seven light transmission observations explainable by special relativity theory. Only five of them are explainable by dragged ether theory. The two that supposedly cannot be explained are stellar aberration and Fizeau convection of light. They will be considered in the next article along with the Sagnac effect, which cannot be explained by special relativity theory [see 25, pp. 282-284; 26, pp. 55-58; 27, pp. 41-43, 247-252; 39, pp. 389-396].

Relational Optics

Four crucial optical phenomena will now be examined in light of the TEEM. The first concerns the behaviors of two coherent beams of light moving on a platform fixed on earth, one beam moving collinearly with the supposed motion of the earth through the ether and the other moving transversely to it. The second concerns the behavior of a beam of light from a source moving transversely with respect to the observer. The third concerns the behavior of a beam of light in a material dielectric moving collinearly with respect to the observer. The fourth concerns the behavior of a beam of light on a turntable rotating with respect to the stars. Three of these were described in an earlier chapter; they will be revisited here and reviewed in the light of the TEEM.

The Michelson-Morley Experiment

This experiment performed in 1887 by A. Michelson and E. Morley was an attempt to measure the effect on optical phenomena of the earth's motion through the luminiferous ether. A beam of light was split into two; one beam was sent in the direction of the earth's supposed movement through the ether and reflected back into an interferometer; the other was sent transverse to the first and reflected back into the interferometer. In the interferometer the two beams interfered and produced a fringe pattern. The distance of travel was the same for both beams. It was expected that the time of travel would be different for both beams and so they would arrive out of phase at the interferometer and produce a shift in the fringe pattern from that expected for no motion through the ether. But no such shift was detected. There are only two reasonable explanations for the null result. The first is that the earth is a rest in the ether; this is held by those who believe in absolute space and that the earth is the center of rest in it. The second is that movement through the ether is a meaningless concept, so that the ether appears to be at rest with respect to all ponderable bodies; this is the assumption of the TEEM. A third explanation, which asserts that the length of the apparatus shrinks in the direction of the earth's supposed motion through the ether, is outlandish.

Stellar Aberration

Stellar aberration, discovered and explained by James Bradley in 1726, is the apparent displacement in the positions of stars attributed to the finite speed of light and to the transverse motion of the earthbound observer with respect to the light beam (ray, photon) from the star.

The effect requires the slanting of a telescope at an angle away from the target star to allow light entering the objective lens to reach the eyepiece. The telescope must be tilted to allow the beam to travel down the axis of a transversely moving telescope. If the speed of light were infinite, that would not be necessary.

Classically, the angle A at which the telescope must be tilted from the vertical for a star directly overhead is given by

> tan A = v/c, where v is the speed of the telescope with respect to the beam and c is the speed of light in a vacuum [see 38, p. 279]
>
> .

According to special relativity theory, using the equations for the addition of velocities, the angle A is given by

> tan A = $(v/c)/\sqrt{1-(v/c)^2}$, which in practice [$(v/c)^2$ small] is indistinguishable from the classical result [see 11 pp. 57-58 and 38, pp. 303, 379-380].

Aberration produces a displacement of 20.5 seconds of arc in the apparent positions of the stars. Since the direction is constantly changing, a star appears to describe a little circle 41 seconds in diameter over the course of a year.

This phenomenon was used as evidence for motion of the earth through absolute space. But Einstein did not see it that way. In the introduction to his 1905 paper he wrote. “Examples of this sort [referring to an electromagnetic phenomenon], together with the unsuccessful attempts to discover any motion of the earth relatively to the “light medium,” suggest that the phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest.”

Panofsky and Phillips [38, p. 282] list several theories (emission theories and special relativity) that do not employ a stationary ether and are

consistent with the phenomenon of aberration. The phenomenon of stellar aberration is also used as evidence to exclude ether drag as explanation for null result in Michelson-Morley experiment [see 38, p. 279]. The argument supposes that the light beam from the star is dragged along in the ether surrounding the earth, which is allegedly moving through absolute space, and therefore aberration would not occur. The drag would impart an additional transverse component of velocity to the beam that would increase its speed with respect to the star. That argument was contested by C. van der Togt [40], who assumed that the speed of light remained the same both with respect to the star and the earth-dragged ether. This puts his dragged-ether model on common ground with both special relativity theory and the TEEM.

In the TEEM, like the special relativity model, aberration is caused by the *relative* motion of the star and the earthbound observer and not by the *absolute* motion of the earthbound observer as in classical theories. Also, the equation for tan A is the same in the TEEM as in the special relativity model because that equation is a consequence of the fact that the speed of the light beam is the same with respect to both the source and the observer. In special relativity theory the cause for that lies in the relative natures of space and time. But in the TEEM it lies in the absolute uniformity of the ether.

The presence of the Lorentz factor,

$$\gamma = 1/\sqrt{1-(v/c)^2},$$

implies that the source and the observer cannot have a relative speed greater that the speed of light.

In the TEEM both the source and the observer can be thought of as possessing the ether as their own because of the impossibility of detecting motion through the ether. Then stellar aberration can be thought of as a kind of refraction, with the interface along the axis of the telescope and the beam passing from a medium with an index of refraction equal to unity into a medium with an index of refraction equal to γ. However, there is no real interface between the two “ethers” because they are really one.

When a beam of light enters or exits one refracting medium into another its speed changes and consequently its wavelength changes also. The ratio of the wavelength of the beam in the first medium to that in the second

medium is equal to the inverse of the ratio of their indices of refraction. In the TEEM the index of refraction for the first medium is unity and for the second medium γ. Thus the wavelength ratio is equal to γ. This agrees with what special relativity gives for the transverse Doppler effect, which it attributes to time dilation [see 11, pp 55-56].

Since the speed of light remains at c along the axis of the telescope, the frequency of the beam must decrease by the factor $1/\gamma$. This is not caused by time dilation, as in special relativity theory, but by a variation in the energy of the beam. Here we employ quantum mechanics which states that the energy of a photon in the beam is proportional to its frequency. The energy and momentum of a photon, like the energy and momentum of a material body, are relative quantities. They will not be the same with respect to different ponderable bodies moving with respect to each other.

The momentum of a photon is inversely proportional to its wavelength. The wavelength of a photon traveling down the telescope tube increases by the factor γ from that emitted by the star, so the momentum of the photon decreases by the factor $1/\gamma$ in the telescope tube. Since in the TEEM the observer always sees himself at rest in the ether he attributes the relative motion to the source. Thus the photon at the source has additional momentum and energy because of the motion of the source. This explains dynamically the increase in wavelength and decrease in frequency of the photon in the telescope tube.

Also, if one assumes that a material body emitted by the star suffers a loss in momentum in the same way as a photon, it follows that the momentum of the body emitted from the star is greater than the momentum observed on earth by the factor γ. Thus the mass of the emitted body is greater than the mass of the observed body by the factor γ. This mass increase is again attributed to the motion of the source.

Fizeau Light Convection

In 1871 G. B. Airy observed stellar aberration with a water-filled telescope. One who believes that the earth moves through the ether would expect to find a larger angle of aberration because of the longer time it takes for a beam of light to travel through water than through air (the speed of light in water is 77% of that in air). However, Airy found no change in the angle. This was not surprising to Airy because A. J. Fresnel had already postulated

in 1818 that there would be a “drag factor.” Fresnel made this postulate to explain an observation of F. Arago. In 1810 Arago observed starlight through a moving plate of glass and concluded from his observations that the earth seems to be at rest in the ether [for details see 39, pp. 123-124]. Fresnel assumed that the ether was partially dragged along by the glass. The drag factor was introduced to harmonize Arago’s observation with the notion that the earth moves through an ether at rest in absolute space. The drag factor of Fresnel is

$f = 1 - 1/n^2$, with n being the index of refraction of the medium.

Fresnel’s drag factor was applied to Airy’s observation. The drag factor compensates for the expected difference in the angle of aberration. The drag factor multiplied by the speed of the telescope through the ether is added to the speed of the light in the medium. This brings the speed of a beam of light in a water-filled telescope up to that in a telescope not filled with water. Thus the angle of aberration is the same for both telescopes.

In 1851 A. H. L. Fizeau devised an experiment to directly observe Fresnel’s assumed ether drag. He set up two parallel tubes of equal length in which he could make water flow at the same speed in opposite directions. He then divided a beam of light into two coherent beams. He shined one beam in the direction of flow in one tube and the other beam opposite to the direction of the flow in the other tube and then reunited the beams in an interferometer. When the water in the two tubes was not flowing both beams arrived at the interferometer in the same phase and produced a fringe pattern. When the water was made to flow a shift in the fringe pattern was observed. This meant that the two beams did not take the same time to travel through the tubes. And from his measurement of the fringe shift Fizeau claimed to confirm Fresnel’s drag factor.

Fresnel’s drag factor f is also called the “Fizeau convection coefficient.” The use of the term “convection” highlights the notion that a material medium imparts some of its speed to a beam of light traveling through it.

Fizeau’s convection coefficient is derived in special relativity by applying the addition of velocities formula to the following scenario: the light moves with respect to the water, which in turn moves with respect to the observer [see 11, pp. 54-55; 38, pp. 302-303]. In the relativistic calculation the beam of light is dragged in inertial space in the direction of

the water's motion. On the other hand, in Fresnel's calculation the ether is dragged.

Fizeau's interpretation of his experiment and thus special relativity's "confirmation" of it has been cogently challenged by G. and V. Sokolov [41]. The Sokolovs argue that Fizeau misinterpreted the interference pattern he observed because he did not take into account the frequency changes that occur when the beams enter and leave the water and the associated phase changes. The frequency of the beam moving in the direction the water flowing at speed v decreases when it enters the water by the factor 1-v/c and the frequency of the other beam increases by the factor 1+v/c, in accordance with the classical Doppler effect. And, with another application of the Doppler effect, both beams emerge from the water with the frequency decreased by the factor $1 - (v/c)^2$ but with different phases. The Sokolovs use a molecular model for the water in which a photon of light in the beam moves through the water intermittently at speed c with respect to the molecules, being absorbed by a molecule and being re-emitted in phase with the absorbed photon a short time later. The time delay between absorption and re-emission is what slows down the progress of the beam giving rise to the index of refraction. The Sokolovs conclude from their analysis that the drag factor is unity and not $f = 1 - 1/n^2$, so that the speeds of the beams in the tubes of the moving water with respect to the laboratory are $c/n \pm v$ and not $c/n \pm fv$, where n is the index of refraction of water. This means that the light beam is completely dragged by the water and not only partially. The factor f is accounted for exactly by the additional phase deviations in the two tubes caused by the frequency differences. The complete dragging by the water contradicts the relativistic equation for the addition of velocities. Furthermore, in the Sokolovs' analysis the expression for f is exact, whereas in the relativistic analysis it is an approximation for small v/c.

The Sokolovs' analysis is in accord with the TEEM. When the water is still, the beam takes more time to move through the water than through the ether alone because of the time delay between the absorption and re-emission of radiation by the water molecules. Thus the beam is slowed down when passing through the water, and moves at the average speed c/n. When the water is flowing at a speed v, the re-emitting water molecules move an additional distance proportional to v (either in the direction of the beam or against the beam) during the time delay between absorption and re-

emission. This additional motion of the molecules causes the overall time for transit through the water to decrease or increase, making the average speed of the beam through the water equal to $c/n \pm v$. An additional note: the index of refraction of water is 1.33 and in Fizeau's experiment the water flowed at seven meters per second, so $c/n \pm v < c$.

Finally, the TEEM easily explains Airy's observation if one, following the Sokolovs, recognizes that even when moving through the water the beam is propagated by the ether at speed c. The molecules of the water are immersed in the ether and act as obstacles that slow down the propagation. The water molecules do not affect the angle of aberration because that depends only on the relative motion of the star and the telescope.

The Sagnac Effect

This effect was discovered in 1913 by G. Sagnac was in an attempt to demonstrate absolute rotation by optical means. A beam of light was split into two; one beam was sent around a turntable in the direction of rotation and reflected into an interferometer; the other was sent around the turntable on the same path as the first but opposite in direction and reflected into the interferometer. When the turntable was not rotating the two beams arrived at the interferometer in phase and produced a fringe pattern. When the turntable was rotated the two beams produced an interference pattern with the fringes shifted from that of the first pattern, which indicated that the optical lengths of the two paths differed. Thus it is claimed that absolute rotation in the ether was demonstrated.

The effect is explained by the TEEM if one recognizes that absolute motion through the ether is meaningless; but motion with respect to an ethereal disturbance, that is, motion with respect to a light beam, produces observable effects. First of all, the motion has an effect on the wavelength and frequency of the beam. This would have some effect on the interference pattern in the experiment. Secondly, the motion of the mirrors would have an effect on the optical length (the distance the beam travels) between mirrors, lengthening it in one direction and shortening it in the other, thus producing a fringe shift. (All motions are referred to the local ether, which is at rest with respect to the earth.) In the Michelson-Morley experiment, on the other hand, there was no movement of the mirrors with respect to the beam, so no fringe shifts were observed. Thus, according to the TEEM, the

Sagnac effect is not a demonstration of absolute rotation but only one of relational motion.

Instantaneous Action at a Distance, Cause Propagation, and Communication

The notion of instantaneous-action-at-a-distance (IAD) is really a combination of two notions, namely, “action-at-a-distance” and “instantaneous.” The first implies the absence of a material medium for the propagation of a physical cause; the second implies an infinite speed of propagation of a physical cause. The first, however, would seem to imply the second if the subject (source of the cause) and the object (recipient of the effect) were somehow linked across space since the beginning of time; for without a physical medium there would be nothing to resist the instantaneous propagation of a physical cause. How could a void have the power to slow down the propagation of a cause? For example, it is impossible to move a massive body across space instantly not because the intervening space resists such movement but because of the inertia of the body resists it. But this inertia could very well be caused by an instantaneous interaction of the body with the rest of the bodies in the universe, a la Ernst Mach.

Unlike relativistic physics, relational physics, of which the TEEM is a part, integrates IAD with non-instantaneous communication of physical disturbances. The notion of IAD accords well with relational mechanics because it does not require the notion of absolute space but only that of relational space. It only concerns the relational aspects of a source and a detector. The properties of the medium have no significance other than providing parameters for the detector’s reaction. IAD effects are also called “non-local” effects. In relativistic jargon, non-local effects lie in the extreme “space-like” region of space-time (events connected by speeds greater than that of light and thus considered unrelated causally). This is the polar opposite of everyday local effects, which lie in the extreme “time-like” region of space-time (events connected by speeds much less than that of light and considered possibly related causally).

The notion of action-at-a-distance probably entered human consciousness with the ruminations of the early astronomers. They believed that the stars directly influence physical processes on earth. In his *Breviloquium*, St. Bonaventure, following the ancient astronomers, said that heavenly bodies influence “the effective production of things generable and corruptible, namely mineral, vegetative, and sensitive life and human

bodies.” But “they are not certain signs of future contingencies, nor do they exert influence upon the freedom of choice through the power of the constellation, which some philosophers say is fate” [Part II, Chapter 14.1]. So he, like other medieval theologians, believed that the stars influenced things on earth. The influences he spoke of were purely physical causes, not occult influences, which could very well be instantaneous.

The notion of IAD was put on firm physical ground by Isaac Newton in his theory of gravity. And the notion is still employed successfully today in the calculation of celestial movements. Newton, although he employed the notion action-at-a-distance because of its usefulness, nevertheless despised it, as the following quotation in a private letter to Richard Bentley reveals:

> It is inconceivable, that innate brute matter, should, without the mediation of anything else, which is not material, operate upon and affect other matter without mutual contact, as it must be, if gravitation, in the sense of Epicurus, be essential and inherent in it. And this is one reason why I desire you would not ascribe innate gravity to me. That gravity should be innate, and essential to matter, so that one body may act upon another at a distance through the vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty and thinking, can ever fall into it. [37, p. 14]

However, Newton’s objection was only a personal prejudice. There is no problem with the concept of gravitational action-at-a-distance if one assumes that gravitational interactions always existed. Such interactions could have easily been set up by God at creation because they contain no contradictions.

When Newton formulated his third law he was apparently thinking of interactions by physical *contact* at the same place. Thus, it makes sense that to him even the transmission of gravitational effects required a medium in contact with massive bodies that conducts their gravitational effects. Thus the change in the disposition of a massive body produces an effect immediately on the medium surrounding it, which in turn propagates that effect to other material bodies. And the medium instantly reacts to that

change thus preserving Newton’s third law in gravitational interactions. However, instantaneous reaction does not logically require physical contact. This notion that it does require physical contact is a consequence of entrenched mechanical thinking.

There is evidence from astronomy and empirical physics that there is *instantaneous* action-at-a-distance in nature. That is, there are physical causes acting over a distance that do not appear to be propagated but rather appear to be communicated as if by contact. Thus the universe in some respects appears to be instantaneously holistic, like a perfectly rigid body. IAD is displayed in gravitational, electromagnetic and quantum phenomena. The evidence from each of those will now be considered:

Gravitation

There is solid evidence that gravitational effects are communicated instantly. E. Mach made a point of this [10, pp. 234-235]. Marquis de Laplace concluded from evidence within the solar system that the propagation of gravity has to be at a speed at least a hundred million times that of light [see 23, Vol. I, p. 207]. Further research has driven that factor even higher. Astronomer T. van Flandern explains why gravitational effects must propagate almost instantly:

> Anyone with a computer and an orbit computation or numerical integration software can verify the consequences of introducing a delay into gravitational interaction. The effect on the computed orbits is usually disastrous because conservation of angular momentum is destroyed. Expressed less technically by Sir Arthur (Eddington), this means: “If the Sun attracts Jupiter toward its present position S, and Jupiter attracts the Sun toward its present position J, the two forces are in the same line and balance. But if the Sun attracts Jupiter to its previous position S’ and Jupiter attracts the Sun toward its previous position J’, when the force of attraction started out to cross the gulf, then the two forces give a couple. This couple will tend to increase the angular momentum of the system. And, acting cumulatively, will soon cause an appreciable change of period,

> disagreeing with observations if the speed is at all comparable with that of light." [as quoted by G. Galeczki in 29, p. 136]

It should be noted here that instantaneous gravitational effects cannot be used by intelligent agents to communicate information instantly because inherent inertial effects in any physical communications system would prevent it.

Also telling is the failure of physicists to discover gravitational waves, something predicted by the theory of general relativity. Much expense and effort has been put into detecting such waves but they have not been observed [see 42]. They are expected to be very weak and therefore very difficult to detect. But perhaps the truth is that they simply do not exist. If they do exist, what is the medium that carries them? There is no medium comparable to the TEEM ether for electromagnetic waves that could do so. And so it seems that, despite Newton's objection and general relativity, IAD remains the only plausible explanation for gravitational interactions.

Electrodynamics

In 1785 Charles-Augustin de Coulomb (1736-1806) formulated a law for the interaction of electric charges that imitated Newton's law of gravitation. Coulomb's law stated that two electric charges attracted or repelled each other in proportion to the product of the magnitudes of their charges and inversely proportional to the square of the distance between them. He assumed no intervening medium and thus introduced action-at-a-distance into electrostatics.

In 1820 André-Marie Ampère (1775-1836) discovered an action-at-a-distance law for the force of interaction between two current-carrying wire elements. In Ampère's law the force of interaction, like that of gravity, varies inversely as the square of the distance between the wire elements [for details see 43].

The idea that electromagnetic IAD (or near IAD) and the finite propagation at the speed of light coexist goes back to the early nineteenth century. A. J. Fresnel believed that the ether behaves like an elastic solid that transmits both longitudinal and transverse waves. Fresnel hypothesized "that the velocity of the longitudinal waves in the ether is indefinitely great compared with that of the transverse waves; for it is found by experiment

with actual substances that the ratio of the velocity of propagation of longitudinal waves to that of transverse waves increases rapidly as the medium becomes softer and more plastic" [23, Vol. I, p. 128].

Michael Faraday (1791-1867) believed that all space was permeated with electric and magnetic lines of force. He proposed that these lines of force replaced the ether and that light and radiant heat might be transverse vibrations propagated along these lines of force [see 23, Vol. I, p. 193]. It seems consistent with his thinking that changes in the dispositions of the sources and sinks could cause instantaneous changes in the lines of force throughout all of space.

Faraday also discovered the phenomenon of electromagnetic induction, a phenomenon that seems to display IAD. Consider a loop of metal wire encircling a magnetic flux. According to the standard formulation of electromagnetic theory, based on Faraday's law of induction, a change in the flux anywhere in the loop is sensed instantaneously in the wire loop by means of an induced current, no matter the size of the loop. So, according to standard electromagnetic theory, a conducting loop light-years in diameter, would instantly have a current induced in it by a change of magnetic flux at its center. T. E. Phipps pointed this out, noting that classical electromagnetic induction theory is "deficient" according to special relativity because it is (wrongly) supposed that special relativity rules out IAD [44, p. 15].

It should be noted here that electromagnetic induction cannot be used to communicate information instantly because the current induced in the wire loop instantly produces a flux at the center of the loop that opposes the flux change there. The net result is that if an instantaneous change in flux at the center of the loop is used to communicate a bit of information to the loop, this communication will be retarded, even though the processes of induction and counter-induction are instantaneous.

J. C. Maxwell, the formulator of classical electromagnetic wave theory, did not rule out the notion of action-at-a-distance. In the preface to the first edition of his famous treatise on electricity and magnetism he distinguishes Faraday's approach (which he adopted) with the action-at-a-distance approach to electromagnetic phenomena:

> … Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centres of force attracting at a distance: Faraday saw a medium where they saw nothing

> but distance: Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids.
>
> When I had translated what I considered to be Faraday's ideas into mathematical form, I found that in general the results of the two methods coincided, so that the same phenomena were accounted for, and the same laws of action deduced by both methods, but that Faraday's methods resembled those in which we begin with the whole and arrive at the parts by analysis, while the ordinary mathematical methods were founded on the principle of beginning with the parts and building up the whole by synthesis. [45, Vol. 1, p. ix]

Maxwell continues on in the preface to compare the work of electromagnetic theorists, W. Weber et al, who interpret electromagnetic phenomena in terms of action-at-a-distance with his own field approach:

> These physical hypotheses [of the action-at-a-distance theorists], however, are entirely alien from the way of looking at things which I adopt, and one object which I have in view is that some of those who wish to study electricity may, by reading this treatise, come to see that there is another way of treating the subject, which is no less fitted to explain the phenomena, and which, though in some parts it may appear less definite, corresponds, as I think, more faithfully with our actual knowledge, both in what it affirms and in what it leaves undecided.
>
> In a philosophical point of view, moreover, it is exceedingly important that two methods should be compared, both of which have succeeded in explaining the principal electromagnetic phenomena, and both of which have attempted to explain the propagation of light as an electromagnetic phenomenon and have actually calculated its velocity, while at the same time the fundamental conceptions of what actually takes place, as well as most of the secondary conceptions of the quantities concerned, are radically different.

> I have therefore taken the part of an advocate rather than that of a judge, and have rather exemplified one method than attempted to give an impartial description of both. [45, Vol. 1, pp. x-xi]

In the last chapter of his treatise Maxwell treats the subject of action-at-a-distance in detail.

In his famous tractate on the principles of dynamics, Maxwell neatly summarizes the difficulty of satisfactorily explaining action-at-a-distance phenomena in terms of an intervening medium. Considering the interaction of two magnets, he concludes:

> Attempts have been made, with a certain amount of success, to analyse this action at a distance into a continuous distribution of stress in an invisible medium, and thus to establish an analogy between magnetic action and the action of a spring or a rope in transmitting force; but still the general fact that strains or changes of configuration are accompanied by stresses and internal forces, and that thereby energy is stored up in a system so strained, remains an ultimate fact which has not yet been explained as the result of any more fundamental principle. [9, p. 67]

The ether that Maxwell apparently envisioned was one with mechanical properties adjusted to provide a consistent theory. It was assumed to pervade all space and matter. It was extremely light and extremely elastic with regard to shear so that it could propagate transverse waves. However, it was incompressible because according to his equations it is incapable of propagating longitudinal waves; yet it could transmit a longitudinal electrical effect instantly. Maxwell's custom was to treat matter as a modification of the ether, so it can be said that he assumed that matter and ether move together [see 23, Vol. I, p. 259]. In his essay *A Dynamical Theory of the Electromagnetic Field*, Maxwell identifies the electromagnetic field with the ether, saying: "The electromagnetic field is that part of space which contains and surrounds bodies in electric or magnetic conditions" [46, p. 34]. Further on he attributes capabilities to the ether other than the transmission of light, which could include IAD:

> A medium having such a constitution may be capable of other kinds of motion and displacement than those which produce the phenomena of light and heat, and some of these may be of such a kind that they may be evidenced to our senses by the phenomena they produce. [46, p. 35]

Maxwellian field theory has its critics. P. W. Bridgman examined the modern concept of light from an operational point of view, that is, from the point of view of what actually can be measured by physical instruments. He concluded:

> Hence from the point of view of operations it is meaningless or trivial to ascribe physical reality to light in intermediate space, and light as a thing traveling must be recognized to be pure invention. [47, p. 153]

The great success of Maxwell's electromagnetic field theory is its ability to predict electromagnetic radiation in free space: According to Phipps, this success lies in predicting the time delay between cause (by the subject) and effect (at the object) and not in describing what is happening between the subject and object:

> Wherein lay the superiority of the field mode of description? Simply in its ability to predict the time delays of causal "propagation." Causes at point A produced later effects at point B, the two being linked by an appearance of something moving from A to B at speed c. (This applies to radiation. Many assume that it applies also to electromagnetic forces, but there is no empirical evidence to back this.) [44, pp. 115-116]

Phipps points out that instant-action models are not limited to instant-action predictions. He cites the work of Gustav Kirchhoff (1824-1887), who, using an instantaneous-action-at-a-distance, many-body interaction model, proved that voltage and current waves travel along wires with the speed of light [see 44, pp.40-41]. He further cites the work of N. Graneau [37, 214-219], "who made computer calculations, using Ampère's original

force law… to show that instant actions of large numbers of coherent current elements separated by distance D in free space from large numbers of coherent elements induce a coherent response in the latter that grows in time and that is delayed in onset proportionally to D. (The delay results jointly from inertial sluggishness of the material current elements and from inverse-square weakening of the Ampère force with distance.) These, broadly speaking, are the characteristics of far-zone radiation, as measured, *e.g.*, by antennas" [44, p. 116]. In order to adequately explain electromagnetic radiation in terms of instantaneous action at a distance Phipps suggests "to follow the Kirchhoff clue and look for some altogether new conceptualization of the many-body problem" [44, p. 120]. J. Fukai made a similar suggestion. He said that Weber's equation (which was the basis for Kirchhoff's calculations) can be applied to the propagation of radiation in a vacuum by considering the vacuum as a "virtual coaxial cable" comprised of virtual positive and negative particles. The "telegraphers" equation of Kirchhoff can then be applied [see 48, pp. 79-82]. Assis made a similar suggestion, using a "photon gas" as a medium of propagation [see 35, pp. 230-231].

J. P. Wesley transformed the IAD Weber equation for the interaction of two charged particles in relational space to field equations in absolute space. [see 26, pp. 217 ff]. In doing so he introduced two new potentials, in addition to the traditional scalar and vector potentials. He maintains that his equations reduce to Maxwell's equations when those new potentials are made to vanish, and when certain restrictions are placed on the traditional scalar and vector potentials. Assis has also shown the compatibility of Weber's equation with Maxwell's equations [see 35, pp. 223 ff].

Graneau's work offers another mode for the communication of physical disturbances in addition to propagation, propulsion and projection. It might be called "postponement" (postponed action). In postponement a physical disturbance is communicated instantly without a medium, but its observable effects are postponed. Inertial and other instantaneous reactionary phenomena and many-body effects delay and weaken the observable effects. Thus a physical disturbance at one place can be communicated instantly to another place in the universe where there is a detector, but the detector will not communicate it instantly to an intelligent observer. Detectors further from the source of disturbance may receive weaker and later effects than detectors closer to the source. Postponement is not the

principal mode of communication of the TEEM, but it does play a role in the mechanism of ethereal propagation.

The prediction by Maxwell's equations of far-zone radiation that transports energy has long been used as "proof" of the independent reality of the electromagnetic field. However Graneau's work has weakened that argument. He essentially showed, using Ampère's law for the force between current-carrying elements, which is an IAD law, that the propagated field may be an illusion caused simply by a delay that increases with distance in the observable effects of an electromagnetic disturbance. This delay is caused jointly by the material inertia of the detector charge and the inverse square weakening of the reaction with distance between the source and detector. Thus "propagated" effects are simply "delayed" effects and not effects transported by the intervening medium.

P. and N. Graneau see hope for such a theory that explains "propagation" in terms of delayed effects:

> Two significant facts emerged from the early investigation [into eddy currents and dynamic induction] which ultimately became responsible for this book. The first was that a Newtonian action at a distance theory could explain precisely the same facts, related to relative motion, as electromagnetic field theory with Einstein's special relativity. The second fact concerned the time delay between the cause of induction and the induced effect itself. This time delay, or the corresponding AC phase shift, could be explained with equal precision by the energy transport time lag of field theory or the many-body simultaneous matter interaction process of Newtonian electrodynamics. The second fact suggests that a time may come when the eight minutes it takes sunlight to reach the earth can be accounted for by a simultaneous far-action theory. [43, p. 140]

Effects that are transmitted instantly are changes of force. Effects that are postponed are changes in energy. Forces produce changes in energy but not instantly because of the inertia of matter. And observers observe the effects of forces (changes of speed, position), not the forces themselves. These effects require time to come about and are therefore delayed. Information is communicated by those effects and not the forces.

It may be that we will not come to understand postponement. But neither do we understand Maxwell's ad hoc vacuum displacement current, which underlies the propagation of electromagnetic waves in free space [see 36, Chapter III] (unless it is indeed as the TEEM proposes), nor do we understand the nature of the photon, which is often pictured more as a projectile than a wave. It is reasonable to believe that postponement can be the basis for a consistent theory for the communication of electrical energy over distance that is as satisfactory as the phenomenon of far-field radiation derived from Maxwell's equations. It may even give insight into the nature of the photon because it, like the quantum-mechanical photon, is connected with instantaneous action at a distance.

Phipps made another pertinent observation about Maxwell's electromagnetic field theory. He said that that theory is in a sense incomplete because it does not provide a force law, a point recognized by Maxwell himself [see 44, pp. 118-120]. Phipps sees no way to get from it to Ampère's force law for current elements or Weber's force law for electric charges (the former can be derived from the latter [see 43, pp. 35-36]). Both Ampère's and Weber's laws presume IAD; and they incorporate Newton's third law with equal and opposite forces acting on the line connecting the two interacting current elements or charges. Traditional electromagnetic field theory requires the addition of a separate force law, which was supplied by H. A. Lorentz (1853-1928). The Lorentz force law violates Newton's third law because the force on a moving charged particle by the field produced by a current element and the reactive force on the current element are not, in general, along the same or parallel lines. The magnetic component of Lorentz's force law is based on the force of interaction between two current elements proposed by H. G. Grassmann (1809-1877). In Grassmann's law, which Grassmann proposed in objection to Ampères law, the forces of interaction between two current elements are generally not collinear or parallel. This non-Newtonian electrodynamics of Grassmann and Lorentz is the electrodynamics employed by Einstein in his special relativity theory [see 43, pp. 28 ff.]. Since the law of conservation of linear momentum is a consequence of Newton's third law, it would seem inconsistent to apply the law of conservation of linear momentum to any inertial situation in special relativity if it does not apply to electromagnetic forces. Special relativity theory gets around this problem by redefining the electric and magnetic fields according to the inertial frame of the observer,

thus eliminating the absoluteness that the fields have in Maxwell's theory [see 48, pp. 2-4].

Despite its being a field theory IAD is actually built in to Maxwell's electromagnetic theory by means of Faraday's law of electromagnetic induction and Maxwell's introduction of vacuum displacement current. The wave equations in free space derived from Maxwell's equations are known to produce "retarded" and "advanced" solutions, and the equations themselves show no inherent preference for either one. The retarded solutions represent electromagnetic disturbances traveling from the source of the disturbance to the detector (absorber) at the speed of light. The advanced solutions, on the other hand, proceed backward in time from the detector to the source and arrive at the source at the time of emission, as if their reaction were an instantaneous reaction. The two solutions are consequences of the time symmetry of Maxwell's equations, and the advanced solution cannot simply be rejected because that would destroy the symmetry. J. A. Wheeler and R. P. Feynman proposed a theory that formulated a combination of both fields and gave the universe as a whole a role as perfect absorber of electromagnetic radiation [see 49, pp. 29-48]. As Feynman explained it: "The combination of the advanced and retarded waves means that at the instant it is accelerated an oscillating charge feels a force from all the charges that are 'going to' absorb its radiated waves" [50, Vol. II, p. 28-8]. This is not strictly IAD because both the advanced and retarded waves travel at the speed of light, one forward in time, the other backward in time. However, it simulates instantaneous action at a distance to the emitter because it receives the reaction of the absorber at the instant of emission. Wheeler and Feynman further affirmed that the electromagnetic field does not have an independent physical existence. They stated: "There is no such concept as 'the' field, an independent entity with degrees of freedom of its own" [51, p. 31, also see pp. 75-79].

A notion introduced into electromagnetic theory after Maxwell is that of retarded action-at-a-distance. This idea admits the absence of a medium but denies instantaneous interactions. Thus the interaction is the transmission of a physical effect by projection somehow. Specifically, impressed *forces* are delayed at the speed of light. It seems that retarded force actions and reactions would wreak havoc with Newton's third law.

Wesley showed that Weber's theory applied to time-retarded fields in free space yields electromagnetic radiation. He concludes:

> Without time retardation the field variables for an action at a distance theory must be regarded as merely a convenient mathematical representation of the direct interaction between the particles. But once the retardation is introduced, a very different physical interpretation becomes necessary. In this case the field must be viewed as having a true physical existence of its own, capable of transmitting energy and momentum. For example, light, as electromagnetic radiation, makes the independent existence of fields evident, quite apart from original sources and final sinks. [26, p. 219].

However, Wesley also makes it clear that one must begin with fields and not forces in order to successfully introduce retardation:

> Although there have been attempts from time to time to introduce the retardation directly into the force laws between two particles without an intermediate field … these attempts have not been successful. The only way to introduce time retardation is apparently via fields! [26, p. 219]

Phipps says that the notion of retarded action-at-a-distance is theoretically arbitrary, not a necessary consequence of Maxwell's equations, and "is utterly devoid of empirical support" [44, pp. 230-231].

Now for some considerations regarding electromagnetic *energy*: In instantaneous action at a distance (Newtonian) electrodynamics electromagnetic energy is conserved non-locally. In contrast, modern electrodynamic field theory *assumes* that energy is conserved locally. It assigns energy to the electromagnetic field, energy that flows through space like a fluid. This is not a direct consequence of Maxwell's equations, but rather it an application of Maxwell's field equations and the Lorentz force law to a postulated continuity equation for the assumed flow of energy in the electromagnetic field. This is the place in the development of electromagnetic field theory where universal IAD is eliminated, thus bringing field theory into concord with special relativity. (Universal instantaneous-action-at-a-distance implies absolute simultaneity, which is not allowed by special relativity theory.) The concept of continually flowing

field energy produces bizarre notions, such as attributing ohmic heating in a current-carrying wire to energy flowing into the wire from the field surrounding it (which is produced by distant charges), rather than to the charge flowing through it. And it produces a plethora of conflicting mathematical expressions for the energy density and energy flow, an ambiguity that Feynman clearly points out. Feynman further points that the actual location in space of the electromagnetic energy is not known with certainty [see 50, Vol. II, Ch. 27].

Electromagnetic field theory has triumphs to its credit; but it has also failed, in both the macroscopic and microscopic domains. P. and N. Graneau show that electromagnetic field theory gives answers that are in conflict with empirical facts. A dramatic example is the measured energy consumption of a rail gun, which differs by orders of magnitude from the value calculated using relativity and field theory [see 43, esp. Ch. 5]. Feynman points out that electromagnetic field theory also fails when it is applied to the electron or any charged particle. It produces an infinity for the self-energy of an electron or point charge, in both the classical and quantized versions, and there is no satisfactory field theory that describes a non-point charge [see 50, Vol. II, Ch. 28].

R. R. Hatch has resurrected the nineteenth-century elastic solid ether concept in a form that he says explains the experimental data and is an alternative to both relativity theory and IAD [see 52].

It may be that instantaneous-action-at-a-distance is the Cinderella of electrodynamics. She in her straightforward unpretentious simplicity has been mistreated and kept out of sight by her ugly but elegantly attired stepsisters, electromagnetic field theory and special relativity. The mathematics of instantaneous-action-at-a-distance is simple and straightforward but awkward and inelegant, while the mathematics of electromagnetic field theory and special relativity is clever and elegant but conceptually deceptive. Perhaps sometime during the twenty-first century a fairy godmother (in the guise of insightful young physicist) will come forth to dress her up in elegant clothing and display her beauty to the world.

Quantum Mechanics

IAD is part and parcel of quantum mechanics. This is especially evident in the phenomenon of entanglement, in which a quantum measurement in one

part of the universe has an instantaneous effect on a measurement in another part of the universe, no matter how far away [see 53]. Two objects are “entangled” if they are connected in such a way that the outcome of a measurement of a given quantum variable for the first object instantly determines the outcome of a measurement of the same variable for the second object. For example, if the measurement of a quantum variable for an entangled object in the first location yields “up,” a measurement of the same variable will necessarily yield “down” for its partner in the second location. And if the measurement of a quantum variable for an entangled object in the first location yields “right,” a measurement of the same variable will necessarily yield “left” for its partner in the second location.

Here is a parable to illustrate the phenomenon: Twin brothers are each given identical magic coins at birth. If one flips his coin and gets heads, the other will get tails when he flips his and vice versa, no matter what their separation.

First observe that the effect must be instantaneous. If it were not, it could be contradicted. Consider what would happen if the communication between the two coins was retarded. The first twin could flip his coin and get a result, say heads. The coin would communicate this result to the second coin, but it would take some time. During the interval of communication the second twin could also flip his coin and get heads thus destroying the effect.

Also observe that the two brothers when separated can never use their coins to communicate with each other because the first must flip his coin; he cannot choose the outcome. All he knows is that when his faraway brother flips his coin he will get the opposite side. One brother can cause something to happen at the other brother’s end, but he cannot control what will happen.

The so-called Copenhagen interpretation of quantum mechanics, championed by Niels Bohr and Werner Heisenberg, implies that things in the submicroscopic world of electrons and other elementary particles behave with pure spontaneity, as if they had free will. Innate randomness is inferred to be part of their nature because some information about them is indeterminate in principle. This view was opposed by the so-called hidden variables interpretation, championed by Albert Einstein and David Bohm, which sees the probabilities of quantum mechanics as caused by an incompleteness of the theory. This incompleteness manifests itself in a lack

of information conveyed to intelligent observers of nature. Hidden variables carry the missing information. John Bell provided a theoretical basis on which experiments could be made to test whether quantum mechanics is complete or incomplete. Such experiments seem to demonstrate that quantum mechanics is complete and that there are no hidden variables, unless the information hidden variables carry could be communicated instantly over any distance (non-locality), which would violate the tenet of relativists that the speed of light is the ultimate speed in the universe. David Bohm formulated a theory employing hidden variables that is equivalent to standard quantum mechanics and retains causality. It is a non-local theory, but the non-locality is not "signal non-locality," that is, intelligent agents cannot use non-locality to communicate instantly because they cannot control the phenomenon [see 54].

Extension, Timekeeping and Mass

The most fundament concepts in physics are space and time. They are treated differently in the logics of Newtonian physics, relativistic physics and relational physics. In Newtonian physics space and time are absolute independent entities with absolute, and not necessarily material, standards of measurement. In relativity, space and time are not absolute but rather relative; different observers will measure different spatial or temporal intervals between events depending on the relative motion of the observers of the events and the presence of gravitational fields. In relational physics, space and time have meaning only in respect to physical objects and physical processes that can be observed and measured. They are not absolute in the Newtonian sense, but they are absolute in the sense that measuring rods and clocks do not, in principle, change according their state of motion or location, as they do in relativity. They can change accidentally, however, because of a change in their specific physical properties because of motion or change of place. Relational physics is down-to-earth because its lengths and time intervals are as invariant as the physical objects and processes that standardize them. Relativity, on the other hand, is cerebral because it is based on mathematical ideas rather than material objects, the forms of equations being invariant rather than standards of length and time.

The measurement of space (extension), time (timekeeping) and the third fundamental concept in physics, mass, will now be discussed in turn.

Extension

Relational physics rejects coordinate systems that "hang loose" in absolute or inertial spaces. Such coordinate systems are sources of much confusion in physics. Relativistic principles, either Galilean or Lorentzian, lead to confusing notions of extension. Extension is ill-defined in relativistic theories; lengths are tenuous, intangible entities. The measuring rods of special relativity are phantom objects, the ghosts of real things.

The relational standard for measuring extension in the laboratory is a rigid rod under given physical conditions, as, for example, pressure and temperature. All other methods of measuring extension are somehow referred back to the rigid rod.

The earth serves as a rigid base on which to construct a coordinate system employing a rigid rod standard. The earth itself approximates a rigid body for laboratory purposes.

The earth also serves as a mini-universe with respect to elementary particles. The relation of elementary particles to the earth is the relation of individual particles with a huge mass of particles bound together rigidly. Thus it is a many body relationship. The earth, being a huge and massive rigid body, is rightly seen as a frame of reference at rest for measurements for distances traversed by elementary particles. Also the elementary particles may have a Machian connection with earth, just as earth has with the rest of the universe. But the motion of an elementary particle with respect to the earth is not reciprocal or relative. One cannot take the elementary particle to be at rest and the earth as moving with respect to it because the physical situation is greatly asymmetric. This does not belie the principles of relational mechanics because relational principles only apply to symmetric situations.

Timekeeping

Relational physics also rejects the ill-defined notion of time in relativity theory. Relativity treats time, like it does space, as a mathematical abstraction. Relational physics, however, treats time as a genuine measure of change in the physical world. And thus it employs real physical clocks, not the nebulous non-physical "clocks" of relativity theory.

Different clocks behave in different ways because of the physical construction. Their timekeeping must always be calibrated against a standard clock, the physical conditions of which are strictly maintained.

Different kinds of clocks behave in different ways and must be compensated in different ways. Following are various kinds of clocks:

1. Astronomical: Employs regular motions of the heavenly bodies relative to earth. Example: sundial.
2. Gravitational: employs regularity produced by constant gravitational force. Examples: pendulum clock, water clock (clepsydra), hourglass.
3. Mechanical: Employs regularity of mechanical process. Example: mass-spring mechanism.

4. Electromechanical: Employs mechanical means for producing regular pulses of electricity. Example: crystal-regulated clock.
5. Electronic: Employs regularity of electronic oscillations. Example: tuned (LC) circuit.
6. Optical: Employs light beam. Example: light clock (consists of two mirrors separated by a rigid rod with a light pulse moving back and forth between them).
7. Atomic: Employs radiation emitted by atoms. Example: cesium clock.

In addition to these are biological "clocks," those inner timekeepers of living organisms that direct maturation of the organisms.

Clock rates are affected by difference in place (gravitational potential energy) and states of motion (kinetic energy) with respect to a master clock, but these effects are not universal for all clocks; they differ from clock to clock, depending on the physical nature of the clock. Following are two examples:

1. The pendulum clock: The period of a pendulum clock is directly proportional to the square root of the length of the pendulum and inversely proportional to the square root of the gravitational acceleration. A pendulum clock that is to be taken to the top of a mountain has to be "compensated" by shortening the pendulum because gravitational acceleration is less at the top of the mountain. If this is not done it will run at a slower rate when it is at the top of the mountain than a "standard" pendulum clock at the bottom of the mountain.

The pendulum clock taken to the top of a mountain will take a definite period of time (duration) according the pendulum clock that remains on the ground. But the period of time registered on the clock traveling up the mountain will depend on the path it takes. That is, different paths that register the same duration for the trip according to the ground clock will register different durations for different paths taken by the traveling clock. This is because the rate of the clock varies as it is taken up the mountain. However the rate of the clock at the top of the mountain will be independent of the path taken. Once the traveling clock reaches the top of the mountain and is

synchronized with the ground clock by a light or radio signal, it will remain in synchronization.

2. The atomic clocks of the Global Positioning System (GPS): Like the pendulum clocks, the rates of the cesium clocks in the GPS system also have to be compensated for the difference in gravitational potential between the satellites and the ground. In addition their rates have to be compensated because they are moving with respect to clocks on the ground. The rates of the satellite clocks have to be compensated by the reciprocal of Lorentz factor ($1/\gamma$) in order to remain in synchronization with the ground clocks. However, the corrections are dynamic and not kinematic, as asserted by special relativity theory. That is, compensation is required because of the physical properties of the clock, not because of “time dilation.” This is evident because the timekeeping is asymmetric; to earthbound observers the clocks in orbit run slower than the clocks on earth but not vice-versa. If relativistic “time dilation” were the cause then clock slowing would be symmetric. The slowing of the orbiting clocks is probably connected to the increased mass of the moving cesium atoms. The increased mass is attributed to the work done on them to put them in orbit [see 44, pp. 139-146, 155-163].

Special relativity theory makes much ado about the synchronization of distant clocks. But it generates complications because it gives a synchronization signal traveling at a finite speed the role of a synchronization signal of infinite speed thus making simultaneity relative. Relational physics also recognizes that compensated distant clocks cannot be synchronized instantly with a master clock because information cannot be communicated instantly, as already indicated. The fastest synchronization signal speed that can be used is the speed of light in a vacuum. However, that does not destroy the notion of absolute simultaneity as it does in special relativity theory. Compensated distant clocks can be synchronized by a light or radio signal with a master clock as follows: The clock to be synchronized sends a light or radio signal to the master clock. The master clock instantly responds with a light or radio signal that contains the time. The time on the distant clock is set in synchronization with the master clock by correcting for the time delay between the sent and

received signal. (The speed of the light signal is the same in both directions because of the dynamical constancy of the speed of light.) The time delay is the time difference from absolute simultaneity. The rate of a distant clock can be compensated in the same way, using more than one signal.

Mass

Mass is measure of the “quantity” of matter in a corporeal body. It is either a measure of the resistance of a body to a change in its state of motion (inertial mass) or a measure of its interaction with other corporeal bodies (gravitational mass). The properties of mass that make it useful as a measure of the quantity of matter are that it is universal, that is, it applies to all material bodies, and that it is additive; that is, the mass of an aggregate of two bodies in identical physical states is the sum of the masses of the individual bodies.

The theory of special relativity predicts that the inertial mass increases by the Lorentz factor γ with the speed of a body with respect to the observer. This is consistent with relational physics, for it was shown in a previous article that the relational interpretation of stellar aberration suggests it. The increasing of mass with speed was inferred before the advent of the theory of relativity from electromagnetic considerations. It is significant only at speeds approaching the speed of light and has been experimentally confirmed.

Newton’s second law states that the force exerted on a body is equal to the rate of change of its momentum; with its momentum, in general, being the product of the Lorentz factor, the rest mass, and the velocity. A simple mathematical integration of the rate of change in momentum with respect to distance from a body at rest to a speed v yields an expression for the kinetic energy imparted to the body. The kinetic energy so calculated manifests itself as an increase in its inertial mass, being expressed by the formula $KE = mc^2 - m_0c^2 = \gamma m_0c^2 - m_0c^2$. When expanded in powers of v, the term m_0c^2 cancels out. The presence of that term led Einstein to propose that even at rest a material body possesses energy by virtue of its inertial mass.. However, relativistic (or relational) dynamics alone cannot verify universal identity of mass and energy (that is, whether they are synonyms for the same underlying physical substratum), nor can it say whether inertial mass can be completely transformed into energy. Those questions were answered

in the affirmative only by further investigations in theoretical and experimental physics.

Although mass is a very important fundamental concept in physics, it is not well understood. Max Jammer concludes his *Concepts of Mass* with the acknowledgment:

> One has to admit that in spite of the concerted effort of physicists and philosophers, mathematicians and logicians, no final clarification of the concept of mass has been reached. The modern physicist may rightfully be proud of his spectacular achievements in science and technology. However, he should always be aware that the foundations of his imposing edifice, the basic notions of his discipline, such as the concept of mass, are entangled with serious uncertainties and perplexing difficulties that have as yet not been resolved. [55, p. 224]

In relational physics, mass is not understood to be an innate property of a body; rather, it is a collective effect on a body caused by its interaction with all the other bodies in the universe [see 8, 29, 34, 37].

CHAPTER SIX: CONCLUSION—PRINCIPLES FOR RELATIONAL COSMOLOGY

A Catholic creation cosmology is one that is totally consistent with empirical facts, with the biblical record, and with the authentic teachings of the Catholic Church. Further, it employs the sound philosophy of nature developed by medieval scholasticism. Cosmologies in vogue today, unfortunately, do not fulfill those requirements. They are based on more on human ideas than on empirical facts, and they do not recognize certain divinely revealed truths about the cosmos and its origin. A cosmology can be genuine only if it starts from true principles, even though such principles may yield more than one consistent cosmology. Following is a set of principles for Catholic creation cosmology that are gleaned from the material presented in this book:

Principle 1: Extension is an absolute accident that depends on matter for its meaning.

The first of the modern philosophers, René Descartes (1596-1650) believed that matter and extension are the same. He held that the concept “void” is a contradiction in terms because where there is space there is by definition extension and therefore matter. Thus for Descartes the universe is a plenum; it is filled, that is all of the places for matter are occupied by matter. This contrasts with the position of St. Thomas Aquinas, who held that the void is a privation, that is, it is a place for matter that is not filled.

The traditional Catholic position, informed by the doctrine of the Eucharist, holds that extension is an “absolute accident.” Being an “accident” means that it depends on matter for its meaning, that is, its existence must always be referred to a material substance. Being “absolute” means that it is separate from a substance in which it inheres, that is, it does not contribute to the essence of a substance. This is in opposition to the doctrine of Descartes, who held that extension is the very essence of material substance. The *Catholic Encyclopedia* (1914) explains this nicely:

> Extension is an “absolute accident,” that is not a mere mode in which the substance exists, as, for instance, are motion and rest. It seems to have a certain distinct entity of its own. This, of

course, would most probably never have been suspected by the human mind unaided by Revelation. But given the doctrine of the Real Presence of Christ in the Sacrament of the Eucharist, wherein the extensional dimensions and sensible qualities of bread and wine persist after the conversion of the substance of bread and wine into His Body and Blood, reason, speculating on the doctrine, discerns some grounds for the possibility of the real distinction and even severance between substance and local extension. In the first place there are motives for inferring a real distinction between substance and extension (actual and local), or, in other words, that extension does not constitute the essence of material substance (as Descartes maintained that it does):

1. Substance is the root principle of action; extension as such is either inactive or at most a proximate principle.
2. Substance is the ground of specification; extension as such is indifferent to any species, since shape or figure which is the dimensional termination of extension depends upon the specific form.
3. Substance is identical in the entire mass and in each of its parts (e.g. in gold), while extension is not the same in the whole and each of its parts.
4. Substance is the principle of unity; extension is the formal principle of plurality.
5. Substance essentially demands three dimensions; extension may be realized in one or two.
6. Substance remaining the same; extension may increase or decrease.

Given a real distinction between extension and substance, no intrinsic impossibility can be proven to exist in the separation of one from the other, for although internal extension naturally demands external, there is no evidence that the demand is so essentially imperative that Omnipotence cannot supernaturally suspend its realization and by other means afford the accidents —extension and the rest—the support which the substance naturally supplies. Since material substance owes the

> distribution of its integral parts to extension, the question arises whether, independently of extension, it possesses any such parts (it, of course, possesses parts essential to corporeal substance, matter and form), or is simple, indivisible. St. Thomas and many others maintain that substance as such is indivisible. Suarez and others hold that it is divisible. [16, article entitled "Extension"]

It is clear that extension does not contribute to the nature of an object if one considers, for example, that the properties a square do not depend on its size and the nature of a bird does not depend on its size. However, relationships with other objects do depend on extension. For example, one can place smaller squares inside a square, and a bird's size will affect how it interacts with its environment. Therefore extension can be said to be "relational."

Principle 2: Interbody extension (space, void) is relational, not absolute.

The first principle applies to a "local" physics, in which the earth (or other ponderable body) is treated as a rigid frame of reference at rest. This second principle applies to a "cosmic" physics, which considers relations between those ponderable bodies. In these relations the void surrounding a ponderable object is considered as an extension of the object. The object thus lends its three-dimensionality to the void surrounding it. The interaction of different objects involves the unifying interpenetration of their individual voids. In such a holistic universe, each ponderable body can be thought of as the core of the universe, the void surrounding it containing the rest of the universe. Nevertheless, Catholic tradition teaches that the earth holds a special place, having been created first; so the universe is not perfectly "democratic," a notion espoused by those who embrace the cosmological principle.

*

Despite its few successes, general relativity has serious deficiencies that call into question its suitability for modeling cosmologies. These deficiencies follow from the fact that general relativity is rooted in the notion that space-

time is an independent physical entity. It was pointed out earlier how general relativity, like Newtonian mechanics, gives inertia to a body alone in empty space. This is an operationally meaningless concept. Einstein himself realized this. He said: “In a consistent theory of relativity there can be no inertia *relatively to “space,”* but only an inertia of masses *relatively to one another*. If, therefore, I have a mass at a sufficient distance from all other masses in the universe, its inertia must fall to zero” [22, p. 180]. Einstein at first thought that this result followed from the general theory of relativity but soon found out that it did not [see references in 8, p. 149]. A. Assis points out other notable defects [8, pp. 146-159]:

1. The requirement of general relativity that the laws of physics have the same mathematical form in all frames of reference, non-accelerated or accelerated, causes confusion and ambiguities. “We need to change many concepts of space, time, measurements, etc. in order for the theory to correctly predict the facts in different accelerated frames of reference. It would be much simpler, more coherent and in agreement with the previous knowledge of the laws of physics to require that each two-body force have the same numerical value (although not necessarily the same form) in all frames of reference.” Assis gives the example of a frame rotating with respect to an inertial frame in Newtonian physics. The mathematical expression for the force on a body is different in both frames but the numerical value is the same. He goes on to say that numerical invariance is implemented in relational mechanics.
2. Einstein wanted to obtain from general relativity the classical centrifugal and Coriolis forces in a body by its rotation relative to the universe. But he was not able to derive the centrifugal force and the correct Coriolis force simultaneously The Coriolis force was five times too large. Also, in such a situation, general relativity yields a spurious axial force that does not appear in Newtonian theory. Thus general relativity cannot yield the correct Newtonian forces in non-inertial frames of reference.
3. Erwin Schrödinger (1887-1961) questioned the equivalence of the precession of the perihelion of Mercury as measured by the astronomers and that calculated by Einstein. Schrödinger said: “After the secular precession of the perihelion of Mercury was deduced, in amazing agreement with experiment, from it, every naïve person had to ask: With respect to *what*, according to the *theory*, does the orbital ellipse perform this

precession, which according to *experience* takes place with respect to the average system of the fixed stars? The answer that one receives is that the theory requires this precession to take place with respect to a coordinate system in which the gravitational potentials should satisfy certain boundary conditions at infinity. However, the connection between these boundary conditions and the presence of the masses of the fixed stars was in no way clear, since these last were not included in the calculation at all" [8, pp. 151-152]. Since the calculation does not take into account the stars and the measurements of the astronomers are with respect to the background of the fixed stars, it would seem that the agreement of Einstein with the astronomers is coincidental.

4. Concerning Newton's bucket experiment: As in Newtonian physics, general relativity does not attribute the concave form of the water surface to the relative rotation of the water with respect to either the bucket or the earth. In addition, general relativity does not attribute the concavity to the relative rotation of the water to the fixed stars and distant galaxies. The consequence is that, in general relativity, the concavity of the water is caused by rotation of the water relative to something completely disconnected from matter. According to the apologetic of general relativity the concavity should be caused by a local curvature of space. But what curves the space in an otherwise empty universe? Furthermore, in the reference frame that rotates with the bucket and the water (when the rotational speed of the water catches up with the bucket) with respect to the fixed stars Newtonian physics adds a centrifugal force term that accounts for the concavity. But general relativity yields in addition to a centrifugal force an axial force that has no analogue in Newtonian theory. The fixed stars do not exert this axial force in a frame at rest with respect to them but does exert it in a frame rotating with respect to them. Since the axis is common to both the non-rotating and rotating frames, this is a contradiction: the same pail of water has a force exerted along its axis and does not have a force exerted along its axis. Also, according to general relativity, in the frame at rest the distant galaxies have no effect on the concavity of the water but in the rotating frame the amount of concavity depends on the mass of the distant galaxies.

5. The parameters of Foucault's pendulum and the flattening of the earth, when calculated according to general relativity in the earth's frame of

reference with the distant galaxies rotating, are different from those observed experimentally.
6. The inertial mass is not well defined in general relativity.

If general relativity cannot give us correct answers about genuine physical phenomena, what credibility are we to give to the exotic notions it inspires, such as the big bang, black holes, white holes and worm holes?

Assis comments on the intricate and cumbersome conceptual and mathematical apparatus of relativity:

> In our view, the theoretical concepts of length contraction, time dilation, Lorentz invariance, Lorentz's transformations, covariant and invariant laws, Minkowski metric, four-dimensional space-time, energy-momentum tensor, Riemannian geometry applied to physics, Schwarzschild line element, tensorial algebras in four-dimensional spaces, quadrivectors, metric tensor g_{mn}, proper time, contravariant, four- vectors and tensors, geodetic lines, Christoffel symbols, super strings, curvature of space, etc. have the same role as the epicycles in the Ptolemaic theory. [8, p. 159]

Assis, following the suggestion of several authors, dispensed with coordinate systems and applied the relational force W. Weber proposed for electrical interactions to gravitational interactions. He was able to implement a mechanics without absolute space and time and without frame dependent forces that gives a clear notion of inertial mass and explains, among other things, centrifugal and Coriolis forces as real forces produced by relative rotation of a body with the distant universe. Assis' relational theory of gravity produces results that are in agreement with experience and are free of contradictions, confusion and ambiguities.

In relational mechanics the measurement of distance on rigid bodies in made with rigid rods. A taut cord can be used to define a straight line. The measurement of distance between rigid bodies is done by laser clocks. In a laser clock a laser beam is reflected back and forth along a measuring rod. To measure a distance between two bodies a light signal is sent from on body to the other and returned. The distance is indicated by the number of cycles recorded by the laser clock during the period of transmittal of the

signal and return. The constancy of the speed of light allows this, the time for the transmitted signal and return signal being the same. These procedures may not always be capable of being performed because of practical considerations. Their purpose is to serve as operational definitions with clear physical meaning.

Relational space (interbody extension) may be Euclidean or non-Euclidean. Operationally, the local geometry of relational space is determined by the communication of three light beams from/to three bodies. The geometry determined by the sum of angles in triangle formed by the three light beams with three bodies at vertexes. If the sum is two right angles then the three bodies define a Euclidean surface, if not, they define a non-Euclidean surface. The geometry would probably depend on the relation of the three bodies with respect to the rest of the massive bodies in the universe. The precession of the perihelion of Mercury might be explained as the result of the triangles formed by the sun, the earth and Mercury defining non-Euclidean surfaces. Thus the precession might be an observational (optical) phenomenon caused by non-Euclidean light trajectories, and not a “curvature of space-time.”

Notice that, although on the Euclidean plane the straight line is a unique path, in general the path defining the shortest distance between two points may not be unique. For example, consider a sphere on an axis: There are an unlimited number of shortest paths from the north pole to the south pole on its surface, all arcs of a great circle. Since the interbody extension between celestial bodies might be defined by non-Euclidean light trajectories, different stellar objects may be the same object viewed along different light trajectories.

Principle 3: Time is relational, not absolute.

Time is not an entity itself. Rather, it is a means of comparing physical changes in different physical objects and is measured by physical devices. Both Newton and Einstein treated time as if it were a substance. For Newton it is a rigid substance which is the same for all who observe it. For Einstein it is a flexible substance that can vary from observer to observer.

Relational physics retains the commonsense notion of absolute simultaneity, even though it cannot be verified directly over large distances by a signal of infinite speed. Two events, no matter how distant from each

other have the same temporal sequence and separation to all observers because all observers can refer their observations to a standard clock, no matter where it is located. The synchronization of clocks presents, in principle, no problem. Clocks can be synchronized unambiguously a by light beam, which has the same speed for all observers because of its dynamical nature.

Principle 4: The speed of light is the same for all moving observers because of its dynamic properties and not because of kinematic properties of clocks and measuring rods.

The speed of light is constant (in uniform gravity) because it is impossible to determine motion though the twofold electrical ether, because of it very nature. If the speed of a light beam varied from body to body, this would imply that that there is a frame of reference in which the beam is at rest. Such a frame of reference would define an absolute space, in which ponderable bodies move at various absolute speeds. Relational physics rejects such a space.

Relative motion is reflected in the change of wavelength and frequencies of a light beam exchanged by two observers on two ponderable bodies moving relatively. The period and wavelength differ by the same factor (γ) resulting in a constant speed. **(**In quantum terms this means that the energy and momentum of a photon are not fixed but its speed is.) This involves a twofold Doppler effect. Both the frequency and wavelength of a beam of light change from physical observer to another physical observer moving with respect to the first but such that the speed of the beam remains fixed. In the classical Doppler effect the wavelength of a disturbance changes when the source moves through the medium and the frequency changes when the detector moves through the medium but the speed through the medium remains constant. However, in relational physics both the source and the detector find themselves at rest in the medium.

*

The TEEM allows for the permittivity and permeability of “free space” to be altered by strong gravitational interaction, giving rise to refraction in the proximity of large massive objects. This would account for the bending of

starlight around the sun and gravitational red shift. This seems to be a more straightforward and natural way to account for such effects than by the distortion of a space-time continuum.

A. K. T. Assis has made a natural connection between gravitation and electromagnetism that makes gravitational effects on the permittivity and permeability of “free space” plausible. He formulated a generalized Weber force law for electromagnetism that includes terms of fourth and higher orders in v/c. He showed that the extra terms yield an attractive force between two neutral dipoles in which the negative charges oscillate around the positions of equilibrium. He concludes: “This attractive force can be interpreted as the usual Newtonian gravitational force as it is of the correct order of magnitude, is along the line joining the dipoles, follows Newton’s action and reaction law, and falls off as the inverse square of the distance” [56a, b].

Principle 5: Natural forces act instantaneously over distance.

Ever since Isaac Newton introduced his law of gravity there has been strong opposition to the notion of instantaneous-action-at-a- distance. Newton himself, even though he framed his law of gravity in a way that implies instantaneous-action-at-a-distance, did not believe in it. However, the stability of a planetary orbit depends on the instantaneous (or near-instantaneous) sensing by both bodies of the change in distance between the sun and the planet. Since Newton believed that gravitational effects were transmitted by an ether, his ether would have to be perfectly rigid in order to communicate changes in force instantly. It seems just as easy to believe that changes in gravitational forces are communicated instantly over space as to believe that they are transmitted by a rigid ether. The former only requires acceptance of the notion that the universe is holistic and not analytic. Although separating the universe into parts has been helpful in explaining some of its features, its complete understanding requires knowledge of the whole.

The same reasoning can be applied to electric and magnetic forces that act along geodesics connecting electric or magnetic objects. Disturbances in the twofold electrical ether are propagated perpendicular to the disturbance at the speed of light. No such propagation exists for gravitational

interactions because there is no twofold medium for them, there being only one kind of gravitational “charge.”

W. D. Walker has shown that, according to Maxwell’s equations, the propagation speed of electromagnetic fields is nearly infinite in the near field and reduces to the speed of light in the far field [57].

Principle 6: Intelligent agents can physically communicate information no faster than the speed of light.

Although longitudinal natural force variations are transmitted over any distance instantly, intelligent agents cannot use them to communicate information instantly. A force can transmit information only by its observable effects (for example, displacement, acceleration). Observable effects take time to manifest themselves. Nature conspires to make us unable to communicate information faster than the speed of light, lest we come to think that we are gods.

Principle 7: The inertia of a material body is caused by gravitational interaction with all the other bodies in the universe.

It was recounted how A. K. T. Assis explained inertia as being the effect of real instantaneous-action-at-a-distance gravitational forces. Applying this notion he recovered Newton’s first and second laws of motion, demonstrated the equivalence of inertial and gravitational mass, and even produced an expression for the precession of the perihelion of Mercury.

Assis’ model of the universe was Euclidean. But logically it need not be so. His notion applied to a non-Euclidean universe would require distances to be measured along geodesics. The equivalence of gravitational and inertial mass insures that the geodesics will be the same for all masses.

Assis’ model is classical; it does not yield an inertial mass that increases with speed, which, apparently, has been experimentally verified. However, a modification of the gravitational interaction might achieve this. The physical problem confronted in determining this term is how to connect optics with mechanics. This is necessary because the mass variation factor, γ, contains the speed of light. Einstein achieved this connection *kinematically* at the expense of Newtonian notions of space and time. The connection can be made in relational mechanics *dynamically* in terms of the

force of interaction between a mass and the rest of the universe. This had already been done by E. Schrödinger in 1925 and independently by J. P. Wesley in 1990 [see 8, pp. 233-236]. However, a good physical explanation should be provided for that interaction. Their introduction of the speed of light seems ad hoc and does not seem to reveal a natural connection between optics and mechanics. Even so, they showed that relational mechanics is capable of explaining mass variation without the bizarre notions of space and time introduced in special relativity.

APPENDIX A: SPECTROSCOPIC BINARIES

A spectroscopic binary star system is composed of two very close stars rotating about each other. Often a spectroscopic binary cannot be resolved optically into two distinct stars and so appears as a single star in the sky. But its optical spectrum contains lines shifted both up and down, from which astronomers deduce that the star is binary. Because of the Doppler effect, the member of the pair moving toward the observer has lines shifted toward shorter wavelengths and the member moving away from the observer has lines shifted to a longer wavelength. The observed wavelength shifts indicate considerably large rotational speeds.

The observations of binary systems have been used to refute Einstein's notion that stellar aberration is caused by the relative motion of the earthbound observer and the observed star and not by the motion of the observer through the ether. Critics of Einstein's view argue that if relative motion causes stellar aberration then the stars in a binary system would not look as close to each other as they do. This is because their great rotational speeds in opposite directions would produce a great difference in their angles of aberration so as to make them look widely separated. [See 58, chapter 11, for a historical summary on spectrographic binaries.]

That argument does not apply to the TEEM, however, because both stars in the binary system can be construed as one star because, being so close together, they produce one ray of light that travels down the telescope tube to the observer. Thus the speed in the angle-of-aberration equation is the speed of the center of mass of the system.

APPENDIX B: OBSERVATIONS PERTAINING TO THE RELATIVE ROTATION OF THE EARTH AND THE STARS

Several experimental observations seem to have been influenced by the relative rotational motion of the earth and stars. The most notable of these is the Hafele and Keating experiment in which atomic clocks were transported in opposite directions around the globe on commercial airline flights. The clocks flown eastward slowed down losing 59 nanoseconds with respect to the clocks at rest on the surface of the earth; and the clocks flown westward sped up gaining 273 nanoseconds. This can be explained relationally by considering the masses of the atoms in the clocks as they move with respect to the stars. The clocks moving eastward have a greater speed with respect to the stars than the clocks at rest. Therefore the masses of the atoms will increase and the clocks correspondingly slowed. Similarly, the clocks moving westward will have a lesser speed with respect to the stars. Therefore their masses will decrease and the clocks correspondingly sped up. [See 58, chapter 16, for a historical summary of this experiment.]

Another pertinent experiment is the Michelson-Gale experiment. In that experiment two beams of light were sent in opposite directions around a large east-west oriented rectangle back to their point of origin. The interference pattern indicated that the optical lengths of the two paths were different. This was interpreted to mean that the speed of the beam travelling east to west was different from that travelling west to east. However, this too might be interpreted relationally. Perhaps it was not the speed of the opposing beams that differed but rather their frequencies and wavelengths. That would also have an effect on the interference pattern. [See 58, chapter 14, for a historical summary of this experiment.]

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Mr. Warkulwiz's interest in electronics led him to physics. He received a Ph.D. in physics from Temple University. At Temple he did experimental work in holography, theoretical work in statistical mechanics, and operated a planetarium. He did his dissertation research at the National Bureau of Standards research reactor, where he gained experience in the fields of precision thermodynamic measurements, cryogenics, vacuum technology, critical phenomena in fluids, neutron diffraction and nuclear instrumentation.

After receiving his Ph.D., Dr. Warkulwiz went to work for the Central Intelligence Agency as a physical scientist/intelligence officer, where he specialized in ballistic missile systems. From there he went on to Magdalen College, NH (now The College of Saint Mary Magdalen) to teach science and mathematics in a "great books" program. At Magdalen he conducted seminar courses in classical mathematics, natural philosophy, astronomy, atomic chemistry and physics, logic, and philosophical biology. He lectured on ancient and medieval history, the history and nature of communism, and creationism vs. the theory of evolution.

Dr. Warkulwiz then went to work for aerospace consultant firms. He worked at Quest Research Corporation, where he did a study of techniques for producing moving infrared images, and at Analytic Services Corporation, where he specialized in space technology. While at Analytic Services, Dr. Warkulwiz heard the call to the priesthood.

In preparing for the priesthood, Fr. Victor received an M.Div. from Mount St. Mary's Seminary and an M.A. in theology from Holy Apostles Seminary. He taught courses in literature, mathematics and physics in the college seminary at Holy Apostles and courses in philosophy and religion at the Franciscan Friars of Mary Immaculate scholasticate. He also conducted Bible and catechism classes in a summer program for youth.

Fr. Victor was ordained a Roman Catholic priest in 1991. He is a member of the Missionary Priests of the Blessed Sacrament and has helped hundreds of parishes in the U.S. and elsewhere to start or maintain perpetual Eucharistic adoration. He was named national director of the Apostolate for Perpetual Eucharist Adoration in October 1998 and theological reviewer for the Kolbe Center for the Study of Creation in 2001. He is profiled in the 2003 and 2004 editions of *Who's Who in America*.

A recent work of the author is *The Doctrines of Genesis 1-11: A Compendium and Defense of Traditional Catholic Theology on Origins* (first printing published by iUniverse, Inc., 2007, www.iuniverse.com; second printing published by The John Paul II Institute of Christian Spirituality, 2009, www.genesis1-11.org). He also edited *St. Lawrence of Brindisi on Creation and the Fall: A Verse by Verse Commentary on Genesis 1-3* (The Kolbe Center for the Study of Creation, 2009, www.kolbecenter.org).